# Crown size and arch width dimension as an indicator in gender determination for a Puducherry population

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#### Abstract

**Introduction:** Tooth morphometry is resistant to postmortem destruction and can be used as an adjunct in skeletal sex and age determination. Therefore, an attempt was made to compare mandibular canine index (MCI) and Pont's index for their level of accuracy in gender determination for a Puducherry population. **Aims and Objectives:** To evaluate crown size and arch width dimension for the Puducherry population using MCI and Pont's index. To compare the MCI and Pont's index, for the level of accuracy in gender determination and to validate its use as a forensic tool. **Materials and Methods:** One hundred and six participants (53 males and 53 females) in the age group of 18–25 years of the Puducherry population were included in the study. Their MCI and Pont's index were recorded. **Results:** The data obtained were subjected to paired *t*-test analysis. It was observed that right MCI was most accurate and molar index was least accurate in sex determination. **Conclusion:** MCI and Pont's index showed significant sexual dimorphism. They can be used as an adjunct to other tools for sex determination and identification of the Puducherry population.

**Key words:** Intercanine distance, intermolar distance, interpremolar distance, mesiodistal width of canine, sexual dimorphism

# Introduction

The identification of human in case of major disasters where bodies are often damaged beyond recognition is a difficult work. Teeth are the hardest and chemically most stable tissues in the body and exhibit least turnover of natural structure. Further, they show significant sexual dimorphism. Thus, they provide excellent materials for forensic studies involving identification of sex.

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Whenever it is possible to predict the sex, identification is simplified because only then the missing persons of one sex need to be considered. The only method that can give completely accurate result is the DNA technique, but in many cases, it cannot be used. This might be due to the expensive, time consuming, and laborious technique of DNA isolation.<sup>[1]</sup>

Teeth may be used for sex determination with the aid of odontometric analysis in which metric parameters of the tooth

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such as mesiodistal, buccolingual width are measured using a vernier caliper.<sup>[2]</sup> Of all teeth in the human dentition, canine, especially the mandibular canine, shows maximum sexual dimorphism and is considered as the "key teeth" for personal identification.<sup>[3]</sup> Studies performed on the lower canine using ratio between mandibular crown width and intercanine width, resulting in a mandibular canine index (MCI), have shown an ability to determine gender with an accuracy of 83.3% in males and 81% in females, by comparing observed MCI with standard MCI value, respectively.<sup>[4]</sup>

Pont's established constant ratio between tooth sizes and arch widths in the maxillary arch in a French population and came to be known as premolar and molar indices.<sup>[5]</sup> This index predicts maxillary dental arch width from the sum of the mesiodistal diameters of the four maxillary incisors. There has been a recent resurgence of interest in the clinical use of premolar and molar indices for establishing sexual dimorphism.

In the light of this background, an attempt is made to compare MCI and Pont's index for their level of accuracy in gender determination for a Puducherry population.

### Materials and Methods

The study was conducted on 106 participants, consisting of 53 males and 53 females in the age group of 18–25 years belonging to the Puducherry population. Individuals with caries-free teeth (or with minimal carious lesion), normal overjet and overbite, and Angel's class I molar and canine relationships were included in our study. However, patients with partial erupted teeth or occlusal abnormalities such as rotation or disharmony or excessive physiologic or pathologic wear and patients with deleterious oral habits such as bruxism and tongue thrusting were excluded from our study.

After complete clinical examination and assessment of participants, alginate impression of both upper and lower arch was made for selected participants, and study model was prepared with dental stone.

The following measurements were recorded on study model:

- Mesiodistal width of the mandibular canines [Figure 1]
- Mandibular intercanine distance [Figure 1]
- Maxillary premolar arch width [Figure 2]
- Maxillary molar arch width [Figure 2]
- Combined width of the maxillary incisors [Figure 2].

#### Formulae

 $Observed MCI = \frac{Mesio - distal crown width}{Mandibular canine}$ Mandibular canine arch width or inter-canine distance



Figure 1: Recording of the measurement for mandibular canine index

Standared MCI = 
$$\frac{(Mean male MCI - SD) + (Mean female MCI + SD)}{2}$$

$$Premolar index = \frac{Sum of incisor \times 100}{Premolar arch width}$$

Molar index =  $\frac{\text{Sum of incisor} \times 100}{\text{Molar arch width}}$ 

Standard premolar index = 
$$\frac{(\text{Mean male PCI - SD}) + (\text{Mean female PCI + SD})}{2}$$
  
Standard molar index = 
$$\frac{(\text{Mean male MCI - SD}) + (\text{Mean female MCI + SD})}{2}$$

The data obtained were subjected to Carlson regression analysis to determine the accuracy level of indices in predicting sex of an individual.

#### Results

It has been observed that mean mesiodistal width of the right mandibular canine was found to be  $6.99 \pm 0.53$  for male and  $6.41 \pm 0.41$  for female. For the left side, mean mesiodistal width of the mandibular canine was found to be  $7.02 \pm 0.60$  for male and  $6.46 \pm 0.40$  for female. The mean mandibular canine distance was found to be  $26.72 \pm 1.69$  for male and  $26.10 \pm 1.42$  for female. The observed right MCI was found to be  $26.23 \pm 2.08$  and  $24.57 \pm 1.79$  for male and female, respectively [Table 1].

The observed left MCI was found to be  $26.32 \pm 2.21$  and  $24.77 \pm 1.64$  for male and female, respectively [Table 2].



Figure 2: Recording of the measurement for Pont's index

For Pont's index, mesiodistal width of maxillary incisors was found to be  $29.97 \pm 2.25$  and  $28.48 \pm 1.58$  for male and female, respectively. Mean premolar widths were  $37.53 \pm 1.85$  and  $36.05 \pm 2.06$  for male and female, respectively. Molar widths were  $49.24 \pm 2.09$  and  $46.31 \pm 1.93$  for male and female, respectively. Observed premolar indices were  $79.88 \pm 5.04$ and  $78.91 \pm 6.31$  for male and female, respectively. Observed molar indices were  $62.13 \pm 5.27$  and  $60.90 \pm 4.41$  for male and female, respectively [Table 3].

Carlson regression analysis was done using Statistica 12 software. Carlson regression analysis is linear regression analysis that could be used for predicting the unknown value of a variable from the known value of another variable. Using regression analysis, equation has been derived to predict the accuracy of sex determination by indices.

### Discussion

Identification of sex from adult human skeletal remains is most reliable if the entire skeleton is available for analysis. However, in the absence of entire skeleton, skull, and teeth often provide the only identification material, and sex determination from these skeletal remains is usually complex.<sup>[6]</sup>

Considering the fact that differences have been established between the odontometric features in specific populations, even within the same population in a historical and evolutional context, it is necessary to determine population-specific values to facilitate identification using dental measurements.<sup>[7]</sup> In general, the dimension of teeth and arch width for either of the jaw is more for male than female.

In our study, we attempted to evaluate crown size and arch width dimension for the Puducherry population using MCI and Pont's index and to compare the MCI and Pont's index

	Table	1:	<b>Parameters</b>	for	canine	index
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	Gender	$Mean \pm SD$	t	Р
MIC distance	Male	26.72±1.69	2.10*	0.03821
	Female	$26.10 \pm 1.42$		
Right MC MD Width	Male	$6.99 \pm 0.53$	6.47**	0.00000
	Female	$6.41 \pm 0.41$		
Left MC MD Width	Male	$7.02 \pm 0.60$	5.72**	0.00000
	Female	$6.46 \pm 0.40$		
Right observed MCI	Male	$6.99 \pm 0.53$	6.47**	0.00000
	Female	$6.41 \pm 0.41$		
Left observed MCI	Male	$7.02 \pm 0.60$	5.72**	0.00000
	Female	$6.46 \pm 0.40$		

\*Significant at 5% level (P<0.05); \*\*Significant at 1% level (P<0.01). MCI: Mandibular canine index, SD: Standard deviation, MD: Mesiodistal, MIC: Mandibular inter canine

Table 2: Standard and observed canine index

Canine	Mear	Standard MCI	
	Male	Female	
Right observed MCI	26.23±2.08	24.57±1.79	25.25
Left observed MCI	$26.32 \pm 2.21$	$24.77 \pm 1.64$	25.26

MCI: Mandibular canine index, SD: Standard deviation

#### **Table 3: Parameters for Pont's index**

	Gender	Mean±SD	t	Р
MD width of maxillary incisors	Male	29.97±2.25	4.05**	0.00010
	Female	$28.48 \pm 1.58$		
Premolar width	Male	$37.53 \pm 1.85$	3.96**	0.00013
	Female	$36.05 \pm 2.06$		
Molar width	Male	$49.24 \pm 2.09$	7.66**	0.00000
	Female	$46.31 \pm 1.93$		
Premolar index	Male	$79.88 {\pm} 5.04$	0.89	0.37338
	Female	$78.91 \pm 6.31$		
Molar index	Male	$62.13 \pm 5.27$	1.33	0.18523
	Female	$60.90 \pm 4.41$		

\*\*Significant at 1% level (P<0.01). SD: Standard deviation, MD: Mesiodistal

for the levels of accuracy in gender determination and to validate its use as a forensic tool.

In our study, 106 participants were included in the study as per the inclusion criteria mentioned in material and method. Standardized methods were used for the measurement of mesiodistal width of the mandibular canine and intercanine distance to calculate MCI. Similarly, for maxillary arch, standardized methods were used for the measurement of mesiodistal width of incisors and premolar and molar width to calculate Pont's index. The mean value and standard deviation were used to derive population specific standard MCI and standard Pont's index (premolar and molar index). Measurements were recorded on the study model using manual vernier caliper.

The standard values for MCI for the right and left side were found to be 25.25 and 25.26, respectively. Similarly, the standard values for maxillary molar and premolar indices were 61.94 and 80.03, respectively. Any observed value of MCI > 25.25 or 25.26 (for right or left side, respectively) was considered male and value less than it was considered female. It has been observed that standard right MCI could predict sex accurately at 75.47% (male - 73.58% and female - 77.36%) and standard left MCI could predict sex accurately at 66.98% (male - 67.92% and female - 66.04%) (P < 0.01) [Table 4]. Similarly, in maxillary arch, if the observed value for premolar and molar indices was found to be greater than standard value, the sex was considered male and value less than it was considered female. Standard premolar index could predict sex accurately at 61.32% (male - 56.60% and female - 66.04%) and standard molar index could predict sex accurately at 53.77% (male - 50.94% and female - 56.60%) (P < 0.01) [Table 5].

The usefulness of the canines as an aid in gender determination by odontometric analyses is supported by their high level of survival in the dentition. The notable difference between canine in determining sex was noted to be due to the nonuniform influence of the Y-chromosome in all teeth. On the other hand, the X-linked genetic influence on tooth width was rather uniform for all teeth.<sup>[8]</sup>

Comparative studies done on changes in arch dimension in early, and late permanent dentition showed more increase in arch width of the maxilla as compared to the mandible in terms of intercanine, interpremolar, and intermolar width with significant sexual dimorphism.<sup>[9,10]</sup> Probability of sex determination was expected to be more when two measurements were considered rather than one. This justifies our choice of MCI and Pont's index for the study

Table	4:	Comparison	of	known	and	estimated	gender	using
standa	ard	value for r	nan	dibular	canii	ne index		

Gender	Number of cases studied	Number and percentage of cases with correct gender prediction using standard MCI						
			Right	Left				
		n	Percentage of accuracy	n	Percentage of accuracy			
Male	53	39	73.58	36	67.92			
Female	53	41	77.36	35	66.04			

MCI: Mandibular canine index

Table 5:	Compariso	on of kn	own and	estimated	gender using
standard	premolar	and mo	lar index	value for	Pont's index

Gender	Number of cases studied	Number and percentage of cases with correct gender prediction using standard premolar and molar indices						
			Premolar	Molar				
		n	Percentage of accuracy	n	Percentage of accuracy			
Male	53	30	56.60	27	50.94			
Female	53	35	66.04	30	56.60			

which is actually a relative value rather than absolute value, and it consists of ratio of mesiodistal width of the mandibular canine and intercanine distance.

The age group of individuals in our study was between 18 and 25 years. Most of the studies done by various authors preferred the age group of 17–21 years considering the complete eruption of canine and minimal attrition of teeth in this age group.

When it comes to the development changes in the arch width, there is no consensus of the age at which the arch attains stability. Changes in intercanine width after the age of 17 years are minimal. In studies done on maxillary arch width, especially on intermolar width, it is seen that there is a change in dimension of arch width observed in late permanent dentition stages (18–25 years) and is reported to increase further.<sup>[10]</sup> To obtain statistically relevant interpretation and with due consideration of the study period and population size (approximately 1,000,000), a sample size consisting of 106 participants was decided. Care was taken that equal number of male and female participants was included in our study.

In our study, we have calculated the standard value of Pont's index for the Puducherry population to determine the sexual dimorphism using this index. To calculate Pont's index, mesiodistal width of maxillary incisors and interpremolar and intermolar width were measured on maxillary casts using manual vernier caliper.

Application of canine index in sex estimation has been validated in various population groups. However, the applicability of this index in sex determination varies in different population as the dimension of teeth, and intercanine arch width varies significantly in people from different racial background. The results of our study showed that MCI as well as Pont's index is applicable for the Puducherry population and showed significant sexual dimorphism.

In our study, using standard right MCI sex could be predicted accurately at 75.47% (male - 73.58% and female - 77.36%) and using standard left MCI sex could be predicted accurately with 66.98% (male - 67.92% and female - 66.04%) [Table 4].

The study conducted by Kaushal *et al.* in a Punjabi population showed that accuracy of canine index in determining sex was 75%.<sup>[11]</sup> Similar kind of study was done by Mughal *et al.* in a Punjabi Pakistani population which showed the accuracy of canine index in determining sex to be 75.97%. Hence, the results of our study are correlating closely with the study done by Mughal *et al.*<sup>[3]</sup>

In our study, right canine index was more accurate in determining sex than left MCI, which is in disagreement with the study done by Kaushal *et al.*,<sup>[12]</sup> but in agreement with the study conducted by Dhara *et al.*, in which right MCI was found to be 52.4% accurate and left canine index was found to be 50.8% accurate in determining the sex of an individual.<sup>[13]</sup>

Gaurav Agnihothri *et al.* conducted a study in a North Indian population to determine the applicability of Pont's index and also to determine the existence of any sexual dimorphism in arch width, if any.

In our study, the results showed not only the existence of correlation between the mesiodistal width of maxillary anterior teeth and premolar and molar arch width but also the existence of sexual dimorphism in premolar and molar indices.

The mean premolar width for male was  $37.53 \pm 1.85$  and for female  $36.05 \pm 2.06$ . The mean molar width for male was  $49.24 \pm 2.09$  and for female was  $46.31 \pm 1.93$  [Table 3]. Mean premolar index was found to be 79.88 and 78.91 for male and female, respectively. Mean molar index was found to be 62.13 and 60.90 for male and female, respectively [Table 6].

These values are closely correlating with the study done in the North Indian population by Agnihothri *et al.* (mean premolar width for male  $38.77 \pm 0.39$  and for female  $37.66 \pm 0.46$ , mean molar width for male  $48.10 \pm 0.10$  and for female  $47.34 \pm 0.19$ , mean premolar index for male 82.0and for female 79.54, and mean molar index for male 66.10and for female 63.42).<sup>[5]</sup>

The mean values of molar and premolar arch width in our study are also correlating with other studies done on different populations. In our study, standard values for premolar and molar indices were also derived for the Puducherry population to determine its accuracy in sex determination. The standard values were 80.03 and 61.94 for premolar and molar index [Table 6].

Our study is the first of this kind to the best of our knowledge in which population-specific standard values for Pont's index were derived. Using standard premolar index sex could be predicted accurately at 61.32% and using standard molar index sex could be predicted accurately at 53.77% (male - 50.94% and female - 56.60%) for the Puducherry population [Table 5].

Table 6:	Standard	and mean	values	for	premolar	and	molar	index
Pont's		Mean+	SD		Sta	ndarı	d index	value

l one o	Inioui		
	Male	Female	
Premolar	79.88±5.04**	78.91±6.31**	80.03
Molar	62.13±5.27**	60.90±4.41**	61.94

\*\*Significant at 1% level (P<0.01); Differ significantly by gender. SD: Standard deviation

When indices were compared for their accuracy in gender determination, MCI was found to be more accurate in gender determination than Pont's index.

There are two components of Pont's index, i.e., premolar and molar index. When all the components of two indices were compared, right canine index was found to be most accurate and molar index was found to be least accurate in sex determination.

In contrary to the study done by Acharya and Mainali on 117 Nepali participants between the age group of 19–28 years in which MCI had shown poor ability of sex assessment<sup>[14]</sup> in our study the sexual dimorphism of canine index was found to be statistically significant. This disagreement may be related to ethnic variation of the two different populations.

Hence, results of our study indicate that dental indices such as canine index and Pont's index show significant sexual dimorphism for the Puducherry population and could be used as an aid in sex determination provided population-specific standard values for these indices are available.

Larger sample size increases the accuracy of result. Small sample size is one of the limitations of our study. Standard value of dental index for a population would be more precise if calculated from a larger sample as it would be a better representative of variation in odontometric measurements in a population.

# Conclusion

Sex determination is a vital step in reconstructing an individual profile from unidentified skeleton remains. Sex may be determined either from the cranium or from the bones of the postcranial skeleton. Among various skeletal parts, the pelvis and skull are traditional sex indicators, but teeth can often be useful when such favorable segments are not available.

In the emerging field of forensic odontology, forensic DNA analysis seems to be a useful technique as it is the most accurate. However, at the same time, it is more time consuming and expensive. Therefore, in developing countries, the establishment of gender of fragmented skeletons grossly destroyed, charred, and mutilated bodies relies on the other methods also which are easy, inexpensive, and accurate.

As means of determining sex, odontometric features have been the subject of research for a long time. The study of the size and shape of the teeth has generated more literature than any other aspect of dental anthropology. One reason for this interest is that tooth crowns are formed to full size in the childhood, before eruption into oral cavity. This permits an interesting dimension of study not accessible with skeletal material for sexual dimorphism.

The advantages of determining sex on the basis of odontometric features are simplicity, speed, and low cost while the greatest disadvantage is the possibility of mistake in the cases where the normal dimensions of teeth are altered due to attrition. Mistakes are possible in the procedure itself due to a lack of referent odontometric values needed for comparison, which leaves room for mistakes in determining sex.

In our study, which was performed on males and females in a definite age group, the odontometric measurements such as mesiodistal width of mandibular canines, mandibular intercanine width, and maxillary interpremolar and intermolar width showed significant sexual dimorphism. The accuracy of sex determination of right MCI, left MCI, premolar index, and molar index were 75.4%, 66.98%, 61.32%, 53.77%, respectively.

Hence, results of our study showed that dental indices such as MCI and Pont's index could be considered as quick, reliable, and reproducible methods of sex determination. They may be used as supplementary tools in sex identification of an individual along with other parameters and methods.

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#### **Conflicts of interest**

There are no conflicts of interest.

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