

## REVIEW ARTICLE

# Dental Cusps: Normal, Supernumerary and Cusp-like Structures—An Overview

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## ABSTRACT

Cusp is an elevation or a mound on the crown portion of the tooth making up a divisional part of the occlusal surface. The occlusal surface of posterior teeth consists of varying number of cusps, which are specific to each tooth. Supernumerary or accessory cusps are the extra number of cusps that occur on the surface of the tooth. These cusps can occur on the posterior teeth, thereby increasing the number of cusps. They can also occur on the anterior teeth as cusp-like structures where cusps are usually not present (for example: talon cusp). Accessory cusps which occur as dental anomalies, such as dens evaginatus are mentioned in the dental literature. Apart from this, the dental anthropology literature also mentions of a number of accessory cusps considered as normal anatomical variants, such as protostylid, parastyle, and so on. Many of these anatomical variants occur as traits in certain racial populations. For the better understanding of the terminologies of these anatomical variants, it is essential to know the different nomenclatures and the various theories proposed to explain the origin of multicusp teeth. This article is therefore aimed at providing the reader an overview of the various dental cusp nomenclatures, theories proposed to explain the origin of multicusp teeth and the supernumerary cusps and cusp-like structures.

**Keywords:** Supernumerary cusp, Anatomical variation, Cusp of Carabelli, Metaconule, Paraconule, Parastyle, Entoconulid, Metaconulid, Protostylid, Dens evaginatus, Talon cusp.

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## INTRODUCTION

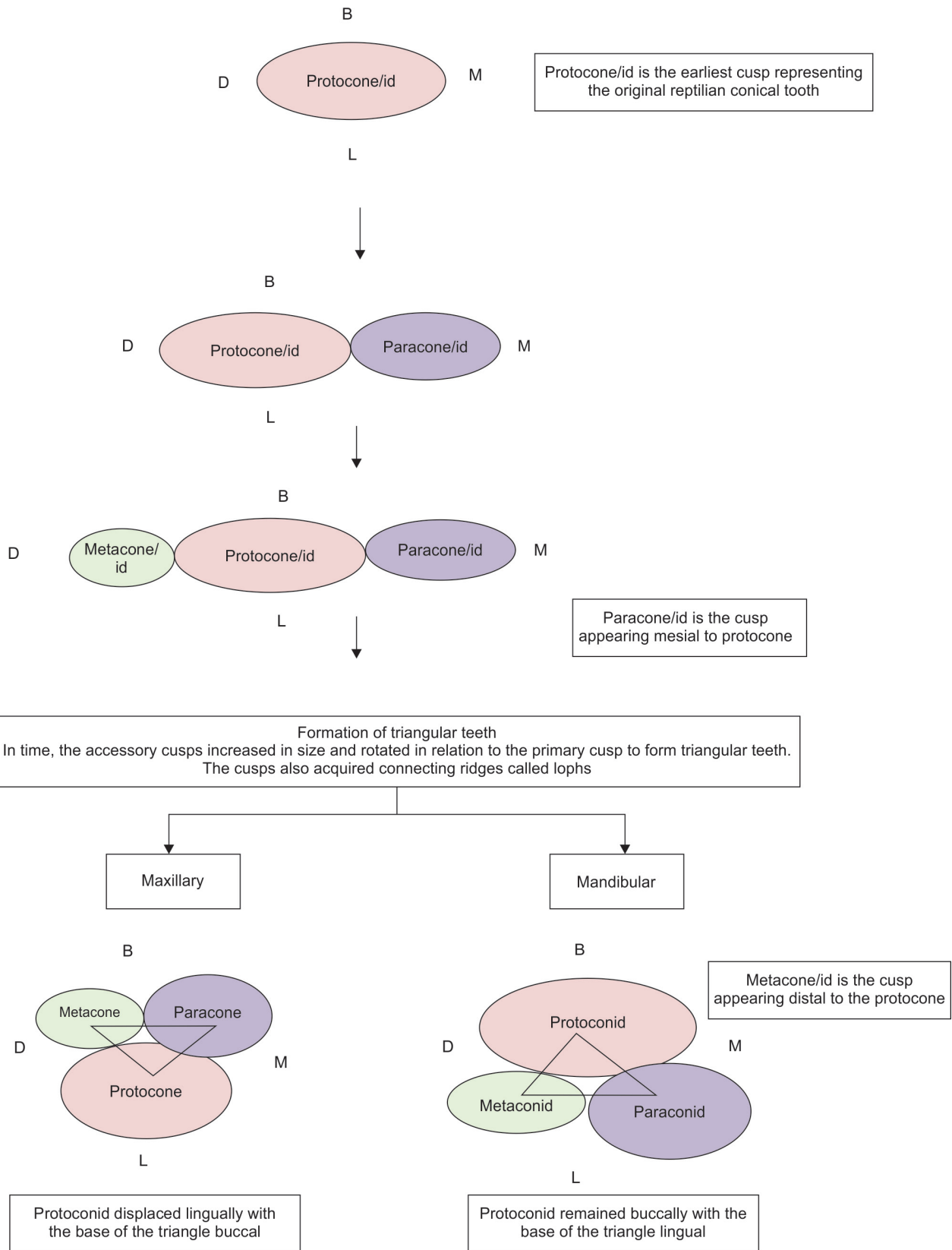
Supernumerary cusps refer to an increase in the number of the cusps. They can occur as dental anomalies (for example: dens evaginatus) as mentioned in the dental literature or can occur as normal anatomical variants (for example: protostylid, parastyle, etc.) as mentioned in the dental anthropology literature. However, these anatomical variants can manifest in the present human population in low frequencies. These structures should therefore be identified and recorded as they have clinical and forensic significance. To understand these structures better, it is important to first note the origin, development and nomenclature of the cusps.

### Origin of Cusps

To explain the origin of multicusp mammalian teeth, many theories have been proposed. Following are the theories of mammalian molar evolution:

- *Concrescence theory:* This theory suggests that teeth in reptiles clustered to form multicusp mammalian teeth.<sup>1</sup>
- *Differentiation theory:* According to this theory, the multicusp mammalian teeth have arisen by budding or outgrowth from the crown of a single conical reptilian tooth.<sup>1</sup>
- *Tritubercular theory:* It was first proposed by American Paleontologist Edward Drinker Cope in 1875 and was later modified by Henry Fairfield Osborn in 1888—'Cope-Osborn Theory'. According to this theory, the simple conical teeth of reptiles (Haplodont, in Greek Haplo means simple) evolved to form multicusp mammalian molars by alignment of mesial and distal cusps forming cusp-in-line pattern followed by shifting of the relative position of these three cusps to form triangular cusp arrangement (tritubercular pattern)<sup>2,3</sup> (Fig. 1).

The triangular arrangement of cusps of upper and lower teeth was reversed in relationship to each other, allowing interdigitation of the triangles in function. This triangular arrangement of the three main cusps (paracone, protocone and metacone) in upper formed the trigon and in the lower (protoconid, metaconid and paraconid) formed the trigonid. These trigon/trigonid teeth could

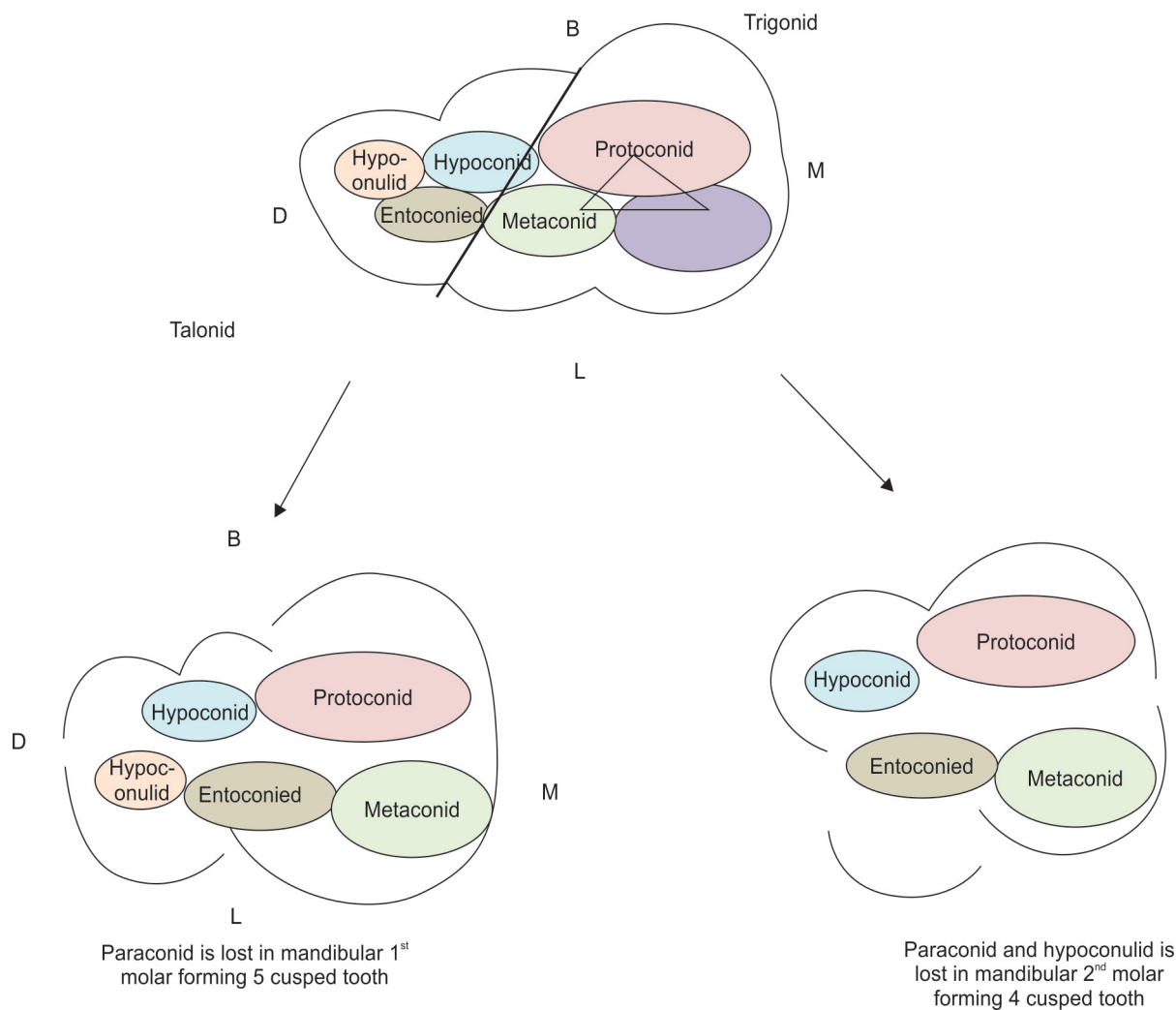


**Fig. 1:** Diagrammatic representation explaining tritubercular theory ('id' is the suffix added describing the same in mandibular structures—protoconid, paraconid and metaconid)

now function by puncturing food as before and also by the shearing action of the crests acting against each other.<sup>2</sup>

As a next step in evolution the talonid (heel) appeared distal to the trigonid in the lower molars which forms

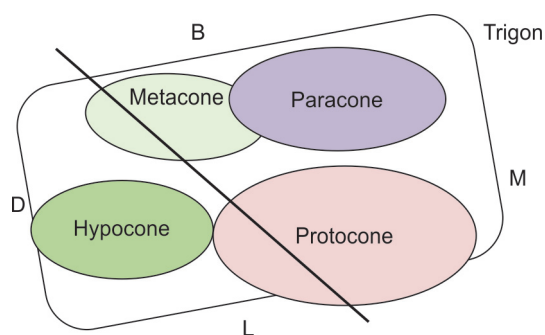
a surface for crushing food against the surface of the protocone in the upper molar. The lower molar talonid gave rise to three cusps, the hypoconid, entoconid and hypoconulid producing six-cusped molar<sup>2</sup> (Fig. 2).



**Fig. 2:** Diagrammatic representation of six-cusped mandibular molars

The triangular pattern of cuspal arrangement forms the tribosphenic molars. The term tribosphenic was first introduced by Simpson in 1936. The tribosphenic molars are capable of both shearing (sphen) and grinding (tribe in) action, providing more versatile occlusal functions<sup>2,3</sup> (Fig. 3).

Small additional cusps appearing mesial and distal to the trigon are protoconule and metaconule respectively and those along the buccal margin are styles—parastyle, mesostyle and metastyle.



**Fig. 3:** Diagrammatic representation of four-cusped maxillary molars by acquiring additional cusp (hypocone on the distal aspect)

The tritubercular terminology is a very useful system for the description of multicusp molar teeth. Though this tritubercular theory is not acceptable as an evolutionary theory, it is more successful with its terms.<sup>2</sup>

**Development of Cusps**

Dental cusps begin to form during the early bell stage of tooth development. Certain activators and inhibitors are produced by the cells of the inner enamel epithelium. The activator produces a primary enamel knot. When the concentration reaches a threshold, an inhibitor is produced which neutralizes the activator. The primary enamel knot subsequently disappears by apoptosis and secondary enamel knot may appear. There are genes that code and control the expression of the activator and inhibitor that modulate the rhythm and quantity of enamel deposition. The primary enamel knot configures the occlusal table of the premolars and molars, while secondary enamel knots individually constitute the cusps during amelogenesis.<sup>4</sup>

According to Turner and Harris (2004), structures like the paramolar tubercle arises during the morphogenesis

**Table 1:** Nomenclature of cusps

	<i>GV Black</i>	<i>Gregory</i>	<i>Henry Osborne</i>
Maxillary molars	Mesiobuccal cusp	Cusp 1	Paracone
	Mesiolingual cusp	Cusp 2	Protocone
	Distobuccal cusp	Cusp 3	Metacone
	Distolingual cusp	Cusp 4	Hypocone
Mandibular molars	Mesiobuccal cusp	Cusp 1	Protoconid
	Mesiolingual cusp	Cusp 2	Metaconid
	Distobuccal cusp	Cusp 3	Hypoconid
	Distolingual cusp	Cusp 4	Entoconid
	Distal cusp	Cusp 5	Hypoconulid

**Table 2:** Osbornian terminology of suffixes and prefixes

<i>Suffix</i>	<i>Implications</i>
Cone	Central primary cusp
Conule	Intermediate cusp
Style	Peripheral cusp arising from the cingulum
Loph (in Greek loph = crest or ridge)	Crest/ridge
id (in Greek id = connected with)	For lower tooth elements (conid, styloid)

process starting from an accessory enamel knot developed at the surface where the feature’s apex forms (Table 1).<sup>4-6</sup>

The most commonly followed dental nomenclature is the one proposed by Black GV, in which tooth components are named according to their position relative to the dental arches/arcades and adjacent structures. This nomenclature is purely based on the location of the cusps (For example: mesiobuccal, distolingual, and so on).<sup>7</sup>

Henry Fairfield Osborn had proposed a nomenclature for the various tooth cusps and elements. This Osbornian terminology was based on a system of prefixes and suffixes, which signified the type, position, relationships of dental elements and also intended to imply evolutionary processes and tendencies (Table 2).<sup>2,3,7</sup>

The prefixes proto, para, meta, hypo, and ento referred to the supposed primitive order of development of the dental elements (in Greek, proto = first in time, para = at the side of and meta = in the midst of or after).<sup>2,3</sup>

In 1916, Gregory numbered the cusps of the molars. This numbering system corresponds to the proposed phylogenetic order of appearance of each cusp in the hominid dentition. In the mandibular molars, since the paraconid disappeared from the trigonid prior to the differentiation of the hominids, it is not included in this numbering scheme.<sup>6</sup>

**DISCUSSION**

The supernumerary cusps or cusp-like structures are either normal anatomical variants or anomalous structures, many of which have a strong racial predilection.

**Accessory Cusps occurring as Anatomical Variants on Maxillary Molars**

*Cusp of Carabelli (Fig. 4)*

It is a structural variation on the mesiolingual aspect of the upper molars in both deciduous and permanent dentition.<sup>5</sup> Cusp or tubercle of Carabelli is named after the Austrian dentist Georg von Carabelli who described it.<sup>8</sup> It

is a supplemental cusp found lingual to the mesiolingual cusp, which merely acts as a buttress or as a supplement to the bulk of mesiolingual cusp. It is an anatomical trait which helps to distinguish between population.<sup>9</sup> It appears frequently and is well developed in caucasoid population and relatively infrequent in noncaucasoids.<sup>10</sup>

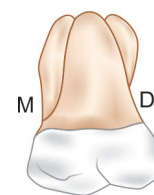
*Metaconule (Cusp 5, Distal Accessory Tubercle)<sup>6</sup> (Fig. 5)*

Metaconule can be defined as an accessory cusp located on the distal border of the maxillary molars between the metacone and the metacone-hypocone distal groove.<sup>11</sup>

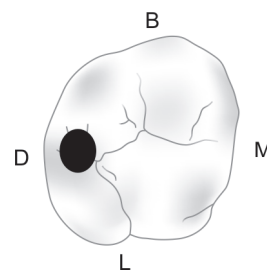
It is usually rounded or conical form and is triangular when its expression is more pronounced. This trait is most common on the maxillary first molar, but often exhibits more pronounced form when it occurs on maxillary second or third molars.<sup>6</sup>

Hanihara (1967) has found metaconule to be very frequent on the deciduous maxillary second molars of the Mongoloid population and has proposed the inclusion of this trait in the ‘Mongoloid dental complex’.<sup>11</sup>

Regarding the terminology, the term cusp 5 has relatively wide usage, but Harris and Bailit (1980) point out



**Fig. 4:** Lingual aspect of maxillary first molar shows cusp of Carabelli on mesiolingual cusp



**Fig. 5:** Occlusal aspect of maxillary first molar shows metaconule

that Black (1902) and other dental anatomists also referred the Carabelli's cusp as the 5th cusp of the maxillary molars. For this reason Harris and Bailit (1980) substituted the term Metaconule for cusp 5.<sup>6</sup>

*Note:* The Mongoloid dental complex consists of Shovel shaped maxillary central incisors, cusp 6/entoconulid, cusp 7/metaconulid, deflecting wrinkle, protostylid in mandibular 1st molar.<sup>10</sup> Cusp 6, cusp 7 and protostylid are described further in this article.

Shovel-shaped maxillary central incisors—these incisors have a pronounced concavity on their lingual surface and elevated marginal ridges which makes them resemble a coal shovel.<sup>12</sup>

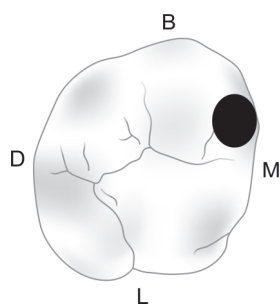
Deflecting wrinkle—the median occlusal ridge of the metaconid (mesiolingual cusp of the mandibular molars) instead of being straight exhibits an angulation which is referred as a deflecting wrinkle.<sup>6</sup>

#### *Paraconule (Fig. 6)*

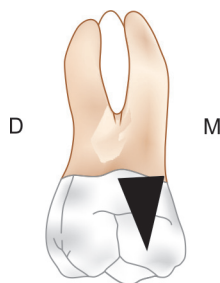
It is said to be a small cusp located on the mesial ridge of the paracone near the protocone.<sup>5</sup>

#### *Paramolar Cusp/Paramolar Tubercle (Fig. 7)*

Bolk in 1916 first described an additional cusp formation on the buccal surface of upper and lower permanent molars and named it as paramolar tubercle. He noted these paramolar tubercles to occur only on the second and third permanent molars and never on the permanent first molars and hence theorized that paramolar cusps represent the occasional atavistic occurrence of additional deciduous molars which are lost in man.<sup>13</sup> However,



**Fig. 6:** Occlusal aspect of maxillary first molar shows paraconule



**Fig. 7:** Buccal aspect of maxillary first molar shows parastyle

Dahlberg and various other authors found paramolar cusp on premolars, lower first molars and upper and lower deciduous molars of modern hominid dentition, ruling out the atavistic occurrence of this cusp.<sup>13,14</sup>

This trait is considered as a cingulum derivative expressed usually on the buccal surface of the paracone of the upper molars and rarely on the metacone of the upper molars and the buccal surface of upper premolars.<sup>6</sup> Dahlberg in 1945 introduced paleontologic nomenclature and referred to these structures as 'protostylid' and 'parastyle' when present in the lower and upper molars respectively.<sup>13</sup> Dahlberg in 1950 defined paramolar as a term applied nonspecifically to a style or cusp of supernumerary character that is developed on the buccal or lingual surfaces of the upper and lower premolars and molars.<sup>4</sup>

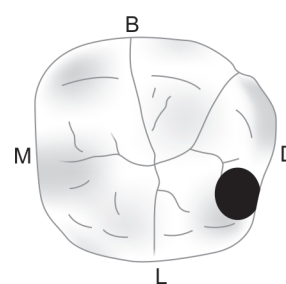
Considering the location and variation of pattern, Kustaloghi OA called these structures as 'upper paramolar structures' or 'upper paramolar complex'. He found their incidence to be low in maxillary first molars when compared to the maxillary second and third molars, and to have bilateral occurrence in deciduous dentition in contrast to the unilateral occurrence in permanent dentition. He also noted its incidence in both the dentitions to be higher in Indians.<sup>13</sup> But, Carolina reports that little information is available regarding its incidence among different races, owing to its overall low occurrence.<sup>4</sup>

The upper paramolar structures (parastyle) are rare in modern hominids, but occur quite frequently in the dentitions of primitive primates and mammals.<sup>13</sup>

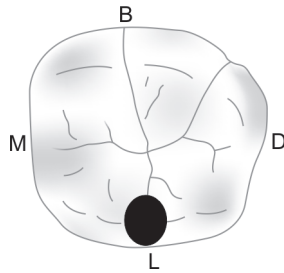
#### **Accessory Cusps occurring as Anatomical Variants on Mandibular Molars (Fig. 8)**

##### *Entoconulid (Cusp 6, Tuberculum Sextant)<sup>15</sup>*

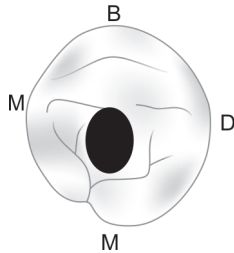
Entoconulid is one of the extra cusps which appear occasionally between the entoconid and hypoconulid in the permanent and deciduous mandibular molars. The incidence has been studied by several investigators and regarded as a racial characteristic. It is found to be a part of Mongoloid dental complex.<sup>10</sup>



**Fig. 8:** Occlusal aspect of mandibular first molar shows entoconulid



**Fig. 9:** Occlusal aspect of mandibular molar shows metaconulid



**Fig. 11:** Occlusal aspect of mandibular first premolar shows dens evaginatus

#### *Metaconulid (Cusp 7, Tuberculum Accessorium Mediale Internum) (Fig. 9)*

Metaconulid occurs in the lingual groove between metaconid and entoconid of the lower molars, most commonly on the first molars. This cusp was originally described by Salenka (1898) who proposed the term tuberculum accessorium mediale internum.<sup>5,10,16</sup>

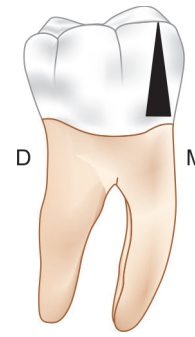
#### *Protostylid (Fig. 10)*

Protostylid is a paramolar cusp on mandibular molars, occurring on the mesiobuccal surface of mesiobuccal cusp, chiefly on the first and third molars.<sup>16</sup> The term protostylid was first proposed by Dahlberg (1945) for a swelling or an extracusp found on the buccal surface of the protoconid in the mandibular molars. Dahlberg reported high frequency of this character in Pima Indians. Later Suzuki and Sakai (1954) found fairly frequent appearance of protostylid in the mandibular molars of Japanese. It is a part of the Mongoloid dental complex.<sup>10</sup>

### **Anomalous Accessory Cusp or Cusp-like Structures occurring on Tooth Surface**

#### *Dens Evaginatus*

The term Dens evaginatus was first recommended by Oehlers in 1967.<sup>17</sup> It is one of the supernumerary cusps considered as anomalous in dental literature. It is a developmental malformation characterized by the presence of an extracusp arising from the occlusal surface of posterior teeth or an accessory cusp like structure arising from the lingual surface (usually) or the facial surface (rarely) of anterior teeth. They are also referred to as central cusps.<sup>18</sup>



**Fig. 10:** Buccal aspect of mandibular molar shows protostylid

The exact mechanism of the formation of dens evaginatus is unknown. It has been postulated that it is caused by an evagination of the internal enamel epithelium and dental papilla into the stratum reticulum during the morphodifferentiation stage of tooth development. The racial difference in prevalence and the higher incidence among first degree relatives suggests a significant genetic component in the etiology.<sup>19</sup>

Dens evaginatus consists of an outer layer of enamel, a core layer of dentin and sometimes a slender extension of pulp tissue into the dentin.<sup>20</sup>

- Dens evaginatus in posterior teeth: Leong's premolar, interstitial cusp, tuberculated premolar, odontome of axial core type, evaginated odontome, occlusal enamel pearl, occlusal anomalous tubercle (Fig. 11).<sup>21-23</sup>

Dens evaginatus is commonly referred as Leong's premolar after MO Leong first described this anomalous premolar at a meeting of the Malayan Dental Association in 1946. It occurs as enamel covered tubercle on the occlusal surface, between the buccal and lingual cusps of posterior teeth. It can occur unilaterally or bilaterally.<sup>24</sup> It is most common among people of Mongoloid racial stock.<sup>25</sup> Rare in Whites and occur in about 15% of Asians. Although it occurs in molars, it is predominant in premolars and is usually bilateral with a marked mandibular predominance.<sup>26</sup>

A predominant association of this dens evaginatus with shovel shaped incisors has been reported. This was seen predominantly in Asians, with 15% prevalence in Whites and close to 100% in native Americans and Alaskans.<sup>26</sup>

#### **Types of Dens Evaginatus in Posterior Teeth: By Schulze (1987)<sup>18</sup>**

- *Type 1:* A cone-like enlargement of the lingual cusp.
- *Type 2:* A tubercle on the inclined plane of the lingual cusp.
- *Type 3:* A cone-like enlargement of buccal cusp.
- *Type 4:* A tubercle on the inclined plane of the buccal cusp.

- *Type 5*: A tubercle arising from the occlusal surface obliterating the central groove.

Kocsis et al have registered 8 types of dens evaginatus, which they regarded as the central cusps in their study on dental casts showing these anomalies on the occlusal surface of posterior teeth and lingual surface of anterior teeth.

### Types of Dens Evaginatus (Central Cusps) by Kocsis et al (2002)<sup>18</sup>

- *Type 1*: Enlargement or bulging on the buccal surface of a lingual cusp of premolars and molars in the faciolingual direction. The lingual cusp is cone-shaped.
- *Type 2*: A macrostructure identified as a supernumerary lobe/central cusp located close to the lingual cusp of premolars and molars, with the existence of the original lingual cusp.
- *Type 3*: A supernumerary cusp on the occlusal surface arising from or near the groove between the original buccal and lingual cusps of premolars and molars. This type is called dens evaginatus.
- *Type 4*: A pearl-like enlargement seen on the lingual surface of a buccal cusp in faciolingual direction on premolars and molars. This central cusp type is the occlusal enamel pearl. It may sometimes occur on canines, too.
- *Type 5*: Bulging of the lingual aspect of a buccal cusp on premolars and molars, and bulging of the lingual aspect of the central lobe on canines and incisors.
- *Type 6*: Various degrees of supernumerary cusp formation on the lingual surface of the anterior teeth, developing from the lingual tuberculum or from the cingulum.
- *Type 7*: Occlusal (or lingual) supernumerary macrostructure of teeth in the case of syndromes.
- *Type 8*: A new central cusp form (type 8) was also recorded. It involves a type 1 and a type 5 central cusp form connected to each other via an enamel ridge and is referred to as a 'margoid central cusp formation'.

### Dens Evaginatus in Anterior Teeth: Talon Cusp

An accessory cusp-like structure occurring on the lingual surface of anterior teeth was first described by Mitchell in 1892, and named as 'talon cusp' by Mellor and Ripa in 1970, because of its resemblance in shape to an eagle's talon.<sup>27,28</sup> It commonly appears as an accessory cusp like structure projecting from the lingual surface of the cingulum. However, there are also reports of this anomaly occurring on the labial surface (Fig. 12).<sup>29</sup>

It affects both deciduous and permanent anterior teeth, with a striking predilection of 75% occurrence in

permanent dentition, and a slight predilection for occurrence in males than females. Between the two arches, the maxillary teeth show 92% predilection over mandibular teeth (Hattab et al). with 55% on lateral incisor and 33% on central incisor.<sup>21</sup>

Talon cusp has been reported to occur unilaterally or bilaterally, on a single tooth or on many teeth. It is also seen to occur with other dental anomalies like supernumerary teeth, odontomas, dens invaginatus, etc. and associated with other syndromes like Struge weber, Rubinstein Taybi, Mohr, etc.<sup>30</sup>

Talon cusp has been classified by Hattab et al:<sup>30</sup>

- *Type 1 (true talon)*: A anatomically well delineated additional cusp that prominently projects from the palatal surface of a primary or permanent anterior tooth and extends at least half the distance from cemento-enamel junction to the incisal edge.
- *Type 2 (semitalon)*: An additional cusp of a millimeter or more but extending less than half the distance from the cemento-enamel junction to the incisal edge. It may blend with the palatal surface or stand away from the rest of the crown.
- *Type 3 (trace talon)*: Enlarged or prominent cingula and their variations, i.e. Conical bifid or tubercle-like.

### CONCLUSION

Various nomenclatures exist for dental cusps. Some are used by dental clinicians and some by dental anthropologists. Dental clinicians stick to the cusp nomenclature given by Black GV, because of its simplicity. However, it is preferable for dental clinicians to be aware of other cusp nomenclatures often used by dental anthropologists like the Osborn nomenclature, as it helps in better understanding of terminologies such as parastyle, protostylid and so on. Rarely accessory cusps occurring as anatomical variants are encountered by the clinicians. However, when found it is important for these nonmetric dental traits to be described systematically (by form and position) in each person's clinical dental history. These

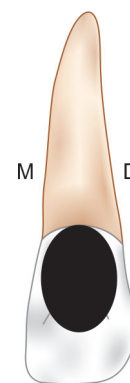


Fig. 12: Lingual aspect of maxillary lateral incisor shows talon cusp

anatomical variants and anomalous supernumerary cusps have definitive racial predilection and are of discriminatory value. Their identification in the process of forensic dentistry cannot be overlooked.

Thus, this article aims to familiarize the clinician with the various anatomical variants and anomalous supernumerary cusps or cusp-like structures, which are rare and often missed during the routine clinical examination.

Once the clinician identifies these structures, he should look for the potential clinical problems they could pose, by which a clinician can evaluate and consider the probable preventive and therapeutic measures more efficiently.

Dental anomalous supernumerary cusps can co-occur with other dental anomalies and/or as a part of the syndrome. Identifying such dental abnormalities should always provoke the clinician to look beyond the lesion. With awareness, more reports of these relatively rare variants and anomalies can be expected, which will help in furthering our knowledge about them.

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