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# Skeletal Biology of human populations between Classical and Post-Classical times in Italy: the evidence of dental enamel hypoplasia

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# Skeletal Biology of Human Populations Between Classical and Post-Classical Times in Italy: The Evidence of Dental Enamel Hypoplasia

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# Biologia scheletrica delle popolazioni umane tra Epoca Classica e Post-Classica in Italia: l'evidenza dell'ipoplasia dello smalto dentale

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Abstract

Linear enamel hypoplasia (LEH) occurs during tooth formation and shows systemic physiological stress caused by various factors, including; malnutrition, congenital genetic defects and infections. It can be identified as pits or grooves, that are mostly visible on the labial side of the teeth crowns. For this work, all the material analyzed come from skeletal remains of classical and post-classical populations from Italy (IV - VIII century AD); it pertains to the cemeteries of Povegliano Veronese (POV), in Verona, Northern Italy, and Selvicciola (SLV) in Viterbo, Central Italy, now stored in the Museum of Anthropology "Giuseppe Sergi" of the Sapienza University of Rome. Linear Enamel Hypoplasia data collected from POV include 56 adult individuals (namely 23 males, 22 females and 11 undetermined), while at SLV, the total population of 120 individuals consists of 29 males, 14 females, 32 undetermined and the rest are infants, children and sub adults. The aim of this research is to provide an overview of the frequency of enamel hypoplasia, the earliest developmental age estimates for the formation of dental enamel hypoplasia as well as the nutritional status in comparing the two populations. Identification, description and assessment through macroscopic analysis were used to investigate the timing of growth of the disturbance. Data obtained from measurements using standardized methods were processed by statistical analysis using a regression equation for estimation of the age of occurrence. The frequency of individuals with LEH at POV is around 41%, while at SLV 37.5% of the population was affected. The age of occurrence of LEH at POV ranges between 1.0/1.5 and 7.1/7.5 years and reaches the peak in the age classe of 2.1/2.5. On the other hand, LEH at SLV is found between 0.0/0.5 and 5.6/6.0 age at death with a peak around 2.1/2.5 and 2.6/3.0. Comparison of LEH chronological distribution based on sex from POV and SLV shows that LEH at POV is dominated by female with a fairly high frequency compared to male, meanwhile in SLV it is the opposite.

Keywords: Linear enamel hypoplasia, Povegliano Veronese, Selvicciola, developmental age defect

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# CHAPTER ONE

# 1. Introduction

## 1.1. Background of Study

Human and zoological remains from archaeological sites, like time capsules, could explain many things that happened in the past through their present discoveries in a number of contexts. Some of these biological remains are found in archeological burials either individual burials or mass burials. In addition, they are also found on natural disaster sites and war sites that occurred in the past. Human remains become objects that continue to be studied to provide a delineation of the past and answer research questions from several experts. According to Buikstra at al. (1990), skeletal biological research continues to experience development during the 19th and early 20th centuries not only focusing on biological variations but has shifted to health and dietary investigations, which in the biodistance[1] has been considered prominent issue of methodology rather than a purely analytical approach.

Furthermore, research on the health aspects of diseases, diet and mobility is carried out through various methodologies, both morphological analysis and technical analytical approaches (Price et al., 2012; Buckley and Buikstra, 2019; Miszkiewicz et al.,2019; Storey et al., 2019; Ortega-Muñoz et al., 2019). Within the perspective of physical anthropology, human skeletal studies aim to reconstruct the past, to understand human variation and population, to provide information about the deceased individuals, ancestry, stature and traumatic injuries (Armelagos, 1990; Işcan, 2005; Brough et all., 2015; Corrieri and Márquez-Grant, 2015). Biological profiles of

[1] Biological distance, or biodistance, is a measure of relatedness or divergence among groups separated by time and/or geography based on morphological variation (Buikstra et al. 1990 in Pietrusewsky, 2014)

the skeletons tell stories about their lives. This goal can be reached through several approaches approaches that could interpret cultural processes, ways of life and cultural history itself (Van Gerven et al., 1973; Crespo-Torres, 2010; Larsen, 2015; Mamede et al., 2018).

One of the approaches used in bioarchaeology is paleopathology, which investigates ancient lesions and diseases in archaeological skeletal remains (Cook, 2015; Bartosiewicz, 2008 in Spigelman and Hoon, 2016) and mummified human remains (Smith, 2016; Lynnerup, 2019). In addition to studying diseases that affect living organisms and their distribution in the past population, this discipline has its roots in the study of abnormalities found in human and animals remains (Schultz et al., 1998; Ortner, 2011; Dutour, 2013; Thomas, 2019). Besides, it could explore changing patterns of human interaction with the nutritional environment, diet and health prehistoric population in the past (Huss-Ashmore, 1982; Dettwyler, 1991; Nelson et al., 2002; Larsen, 2003; Bocca et al., 2018) and sometimes related to political and social aspects (Grauer, 2018).

Even an in-depth interdisciplinary effort, covering aspects of biomedical sciences, humanities, and social sciences as well as relationship with medical sciences has remained essential (Buikstra et al., 2017; Ortner, 2011; Mays, 2012; Katzenberg and Grauer, 2018). however, in providing explanations related to the research objectives to be achieved have differences in methodology and evidence base between clinical studies and modern paleopathology (Mays, 2018). The undeniable thing is that this discipline was initially pioneered by 19th-century physicians and anatomists such as Rudolf Virchow (1821-1902), Frederic Wood Jones (1879-1954), and Grafton Elliot Smith (1871-1937) in giving explanations to the etiology of lesions in mummies and skeletons. Sir Marc Armand Ruffer (1859–1917) was later known as the pioneer of paleopathology from the British Institute of Preventative Medicine developed by Sandison (1996) who adopted a clinical approach in interpreting past diseases (Katzenberg and

Grauer, 2018) Furthermore, as we understand that paleopathologists identify diseases from bioarchaeological remains by observing bone lesions found in individuals, we should be aware that there are several hypotheses and questions related to the occurrence of a disease. Further, we should bear in mind that some individuals who die immediately after contracting the disease will not show signs of disease in their bones. In contrast to those who are able to live in a long time with the disease will certainly experience clear lesions on the bone. Therefore, Wood et al., (1992) propose an osteological paradox by concluding that a person's relative health is due to reactions and bone lesions in the bone. In order to avoid misinterpretation and ignorance about the absence of disease or rarely existed in ancient times (Cohen et al., 1994; Wright and Yoder, 2003; Siek, 2013).

During the last decades, paleopathological research has experienced rapid development, although many criticisms related to the methods used sometimes hamper its development. But with several approaches and research advances supported by several analytic techniques, it is possible to produce research that can be accounted for. Such is often in the form of ecological, evolutionary, and epidemiological approaches (Zuckerman et al., 2012). In addition, the results of paleopathological investigations on the remains of prehistoric and historical population skeletons provide information related to living conditions, such as nutrition, housing and working conditions in ancient times (Schultz et all., 1998). Nerlich and Lösch (2009), in their research on paleopathology remnants of human skeletal remains from Egypt, Sudan, Hungary, Latvia and South Germany to determine the origin and evolution of tuberculosis and their pathogens (Mycobacterium tuberculosis complex) explain the existence of molecular evolutionary relationships, their distribution and environmental correlations. In addition, Roberts and Buikstra, (2003), focus their research on the evolution and development of paleopathological tuberculosis (TB) in ancient times by explaining the history of infectious diseases, which include their etiology, epidemiology, and pathogenesis. With strong evidence from the archaeological record through the analysis of human and non-human skeletons there has been an increase in tuberculosis repeatedly as society develops increasingly economically, socially and politically.

Diseases arising from transmission from human relationships with animals cannot be denied because animals and humans have a closeness since the domestication of animals. Through the development and application of bimolecular approaches and techniques to study zoo archaeological remnants, allowing identification of infectious organisms between humans and animals (Siegel, 1976; Upex and Dobney, 2012). In addition, molecular DNA studies in human remains could provide a description of the epidemiology of past societies (Littman, 2009; Mulhall, 2019 Patel, 2019). Moreover, isotope analysis in the human skeleton not only provides information about diet and migration but also about past population diseases that are sometimes linked to nutrition (Curate, 2016; Nelson, Halling and Buikstra, 2016; Scorrano, Zariſa, 2016; 2018; Toso et al., 2019; Curto et all., 2019) even this approach becomes a very important issue in exploiting recent advances and future prospects in the application of stable isotope ratio data to human paleopathology (Reitsema and Holder, 2018).

### 1.1.1. Enamel Hypoplasia Studies

The results of the research prove that in addition to the skeleton, teeth can also be used as a fundamental tool in assessing overall health and living conditions of past population (Przystańska at al., 2017). Dental Enamel Hypoplasia (DEH) or Linear Enamel Hypoplasia (LEH) is a term to describe defect in teeth associated with ongoing physiological disorders of enamel matrix secretions during childhood (Kronfeld and Schour, 1939; Goodman and Rose, 1990; Guatelli-Steinberg et al., 2004; Witzel at al., 2008; Hubbard et al., 2009; Henriquez and

Oxenham, 2017; McGrath et al., 2018; Masotti et al., 2019). It consists of deficiency of enamel thickness caused by physiological disturbance (stress) during the secretion phase of amelogenesis[2] (Goodman and Rose, 1990), that is mostly used by bioarchaeologists for past human health appraisal in the study of paleopathology.

Hypoplastic defects in teeth occur in the form of pits, grooves or large areas of missing enamel (Hilson, 1996; Guatelli-Steinberg et al., 2004; Marchewka et al., 2014) and often found in horizontal and linear appearance (Psoter, Reid and Katz, 2005) (fig. 1.1). Linear Enamel Hypoplasia (LEH) can be found in all types of teeth, but it is mostly identified in anterior teeth, as incisors and canines, specifically on the labial side on teeth. Rarely, there are defects in premolar teeth or molars, although there have been many studies in recent decades showing patterns in the distribution of linear enamel hypoplasia throughout all of the teeth (Nelson, 2018).

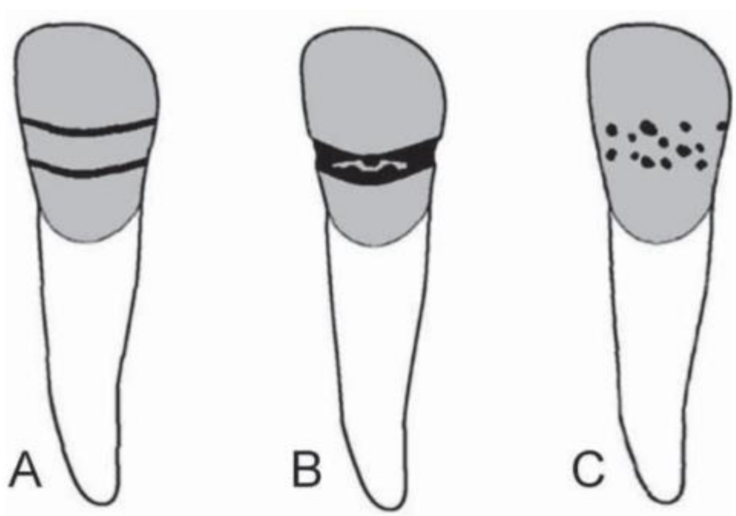


Figure (1.1). Type of enamel hypoplasia A- Horizontal line; B – Grooves; C – Series of pits (Marchewka *et al*., 2014)

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[2] Amelogenesis or Amelognesis imperfecta (AI) is a condition of development, of genomic origin, which enhances the structure and clinical development of enamel of some or more of all teeth in less the same way that is usually associated with morphological or biochemical changes in the body (Crawford et al., 2007; Gadhia et al., 2012)

In modern research, the presence of stress markers on teeth (defects) is caused by several factors including the effects of congenital infections, parasitic infections, starvation or low birth weight. (Reid and Dean, 2000; Ritzman et al., 2008; Caufield et al., 2012). Environmental, proprietary or idiopathic factors (Gupta et al., 2014; Anthonappa and King, 2015) and food and infectious diseases also can cause tooth abnormalities (Benderlioglu and Guatelli-Steinberg, 2019). In addition, it is caused by malnutrition and febrile illness, which results in systemic physiological stress that occurs when different teeth form at the same time (Goodman and Rose, 1990; Hilson, 1996; Nanci, 2017), associated with vitamin D deficiencies (Reed et al., 2017) and cultural practices that influence health (Nelson, 2018). According to Psoter, Reid and Katz (2005), malnutrition has been associated with dentition caries, and epidemiological studies have suggested and conclude a relationship between caries, enamel hypoplasia and protein-energy malnutrition (PEM) (Matee, et al., 1992; Li et al., 1996; Skinner and Skinner, 2017; El- Bayoumy et al., 2019).

Etiological factors as a cause of enamel defects non-fluoride are divided into two parts, systemic; include chromosomal abnormalities, congenital abnormalities, congenital errors, neonatal disorders, infectious diseases, neurological disorders, endcrinopathy, nutritional deficiencies, nephropathy, enteropathy, liver and poisoning while local factors associated with traumatic osteitis and periapical primary teeth (Pindborg, 1982). Furthermore, other hypotheses suggest that the appearance of defects in teeth may be caused by parasitism (Suckling, Elliott and Thurley, 1983; 1986), Haemolytic anaemia (Pindborg, 1982), weaning processes (Goodman and Rose, 1990; Skinner, Skinner and Boesch, 2012) and seasonality (Skinner and Pruetz, 2012).

Linear enamel hypoplasia research has been carried out not only in humans but also in mammals such orangutans, apes, monkey, pig and sheep that are part of zoo archaeology research.

LEH studies in animals have mostly focused on domesticated animal populations found at archeological sites. Archaeological pig teeth, for instance, researchers have tried to investigate the relationship between LEH patterns and the physiology of animal development that might provide an interpretation of the causes of LEH from birth and weaning factors as well as the environment by comparing modern domestication in pigs (Dobney and Ervynck, 1998; 2000; Dobney et al., 2002; Teegen and Kyselý, 2016). Also information on age at death, killing season, and season of birth data (Pike-Tay, et al., 2016) as well as DEH tooth changes are found in bighorn sheep caused by nutritional deficits on the influence of climate (Lyman, 2018).

Examination of hypoplastic enamel in other animals including large mammals such as horses and bison, illustrates the relationship of LEH with nutritional issues originating from climate change as a cause of animal health (Barrón-Ortiz et al., 2019). LEH also affects not only domesticated but also wild animals, the results of research on giraffes (*Giraffa camelopardalis*) show that wild giraffe animals are relatively less stressed because they have no linear defects compared to captive giraffes (Franz-Odendaal, 2004). Despite the environmental role is very influential in places animal life that has an impact on their health (Franz-Odendaal et al., 2003).

The relationship between LEH patterns and the normal developmental physiology of some animals opens up a number of possibilities for interpretation. Non-human primates, *Pan troglodytes* and *Gorilla gorillas* (wild African) and *Pongo pygmaeus* a type of apes from Asia show the presence of repetitive linear enamel hypoplasia (rLEH) as a result of environmental influences (rainy or dry maxima) which causes the possibility of disease and malnutrition in primates (Skinner and Hopwood, 2004; Skinner, 2014). The same thing with chimpanzees (*Pan troglodytes verus*) from Fongoli, Senegal (Skinner and Pruetz, 2012). While Newell et al (2006), see linear enamel hypoplasia (LEH) on taxonomic patterns in the distribution of LEH that are closely related to the length of maturity in all primate orders, his research explores the relationship between maturation length and frequency of LEH in *Ceboidea* family.

In humans, enamel hypoplasia illustrates that the rate of development and geometry of the crown may influence the ability of the crown to record the occurrence of stress arising in the teeth (Goodman and Armelagos, 1985). The results of the study, showed that the presence of defects in tooth enamel associated with the formation of LEH is a result of malnutrition in these individuals and can also be associated with less diversified nutrition (Goodman et all., 1991; Goodman and Rose, 1991; Cucina, 2002; Goodman, 2017; Buckwalter and Baten, 2019). Dental records in the form of defects in the form of pits or grooves were identified as enamel hypoplastic patterns from the ancient cemetery site in St. Austrian Pöltendi is used for diagnosis of congenital syphilis as the first case in Pre-Columbian Central Europe (Gaul et al., 2015). Furthermore, enamel hypoplasia data on teeth is used as a basis in providing nutritional and health assessment from archaeological evidence to see gender equality in Scandinavian society.

From the research showing that the health value of Scandinavian women in rural areas has had a fairly good nutritional health value during the Era Viking, medieval and later periods (Buckwalter and Baten, 2019). Walker et al., 2019, explained that the growth of the human skeleton in the early Middle Ages (English skeletal collection in Canterbury) showed that individuals from high economic status classes were more likely to develop bone density as adults even though in childhood experienced health problems which is seen by comparing linear enamel hypoplasia (LEH) for health proxies in children and mid-shaft femur (OPD) osteon population densities as proxies in adult bones.

Moreover, linear enamel hypoplasia studies compared the early Neolithic, Copper and Bronze Age populations of the Trento region, northern Italy. The results of this study indicate that the high frequency of enamel defects and earlier chronological onset in the Early Bronze Age population compared to the early Neolithic, this is associated with less diversified nutrition, increased sedentism[3] and a higher risk of disease (Cucina, 2002). LEH investigations are high on the remaining skeletons of two archeological sites in northern Italy; the Castello del Tartaro site which is the site of the late Bronze Age in the Verona region and the Spina iron age site in the Ferrara section. The high LEH proposition from the Castello del Tartaro site compared to Spina illustrates that the nutritional and health conditions of the bronze age population are worse than the iron age Etruscan community in Spina (Gualdi-Russo et al., 2017) the fact that the Etruscan city had its large commercial port on the Adriatic Sea at that time (Ferri, et al., 2006 in Gualdi-Russo et al., 2017).

### 1.1.2. Research Objective

In this study objectives to identify the profile (composition of the population) of the classical and post-classical ages populations and compare skeletal collections from those collections to check possible changes among people from the same necropolis (intra-population changes) and between the individuals from the SLV and POV (inter-population changes) with the special aims to;

a) Determine the frequency of enamel hypoplasia,

b) Characterize the types of hyperplastic defects,

c) Estimate the developmental age of the earliest formation of enamel hypoplasia

[3] In anthropology and archeology, sedentism is interpreted as the transition from a nomadic society to a lifestyle that involves staying permanently in one place. Basically, sedentism means living in groups permanently in one place (Weber and Horst, 2011)

## 1.2. Context of The Site

### 1.2.1. Povegliano Veronese (POV)


Figure (1.2). Map of Italy (www.mapsofworld.com) and Figure (1.3) The location of Povegliano Veronese (POV) area in map (www.google.com/maps)

Povegliano Veronese (POV) site is located in the province of Verona in the Italian region of Veneto, located about 110 kilometers west of Venice in the Northern Italy (fig. 1.2). The Povegliano Veronese cemetery is in the area of "Madonna dell'Uva Secca with a coordinate point of 45°20′50.28″N 10°52′50.02″E. This is along the ancient *via Postumia*, which is one of the main streets of ancient Rome Northern Italy (Micarelli et al., 2018) (fig. 1.3). This area is located in the territorial highlands and lowlands. In the area there are springs from the Tartaro river, whose path crosses west to the surrounding tributaries making the area often used as a protected forest area.

The northernmost part, is characterized by the presence of a gravel subsoil (mostly moraine debris) and scarce water, has yielded few traces of ancient human occupation; In the northeast, the city of Povegliano lies on the back of a pebble stone at a slightly higher altitude (around 47 meters above sea level) with a relatively dry area. In addition, early medieval documents mention that in that era there was a habitat with swampy areas and extensive forests (Giostra, 2014).

The systematic study of the Longboard Necropolis between the 1980s and 1990s found several settlement structures and landscapes connoted between ancient times and the early Middle Ages, (Bruno and Giostra, 2012). Based on data, the area of site was excavated during two field sessions in 1985 -1986 and 1992-1993 (Micarelli et al., 2018). In these excavations, most were found settlement structure also burials separate in the region with concentrations of burials in the area of the city of Madonna dell'Uva Secca. Archaeological findings found in the funeral area suggest the chronological frame between the end of the VI and the beginning of the VIII century (Giostra, 2017) (fig. 1.4-1.6).

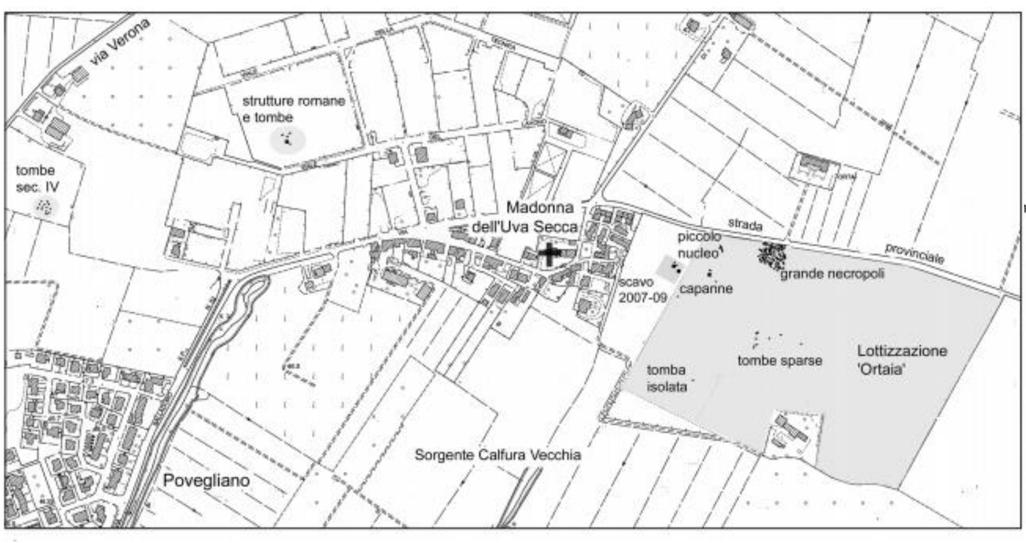



Figure (1.4). Map of area the Poveliano Veronese site and Figure (1.5). The discovery of Fibula artifacts in the shape of the letter "S" which is jewelry and clothing accessories found in women's burials and Figure (1.6). Gold paper in the shape of a cross (Bruno and Giostra, 2012).

Burial patterns based on gender indicate that the *sex ratio* appears almost the same in a burial complex. The grave goods were the key to read the differences between male and female when there was not the possibility to investigate the biological. Women's burials are included in clothing accessories such as the brooch (figure 1.5) while men with weapons with some related accessories such as shields, spear arrows and scramasax. Although in the 7th century there was a reduction in the length of the scramasax (Bruno and Giostra, 2012). In addition, in the north of the funeral area there is the burial of animals with a horse and two dogs. Likely this was interpreted as an animal sacrifice, because of the decapitated horse. In addition, some burials were found as a tomb stock such weapons. Those burial pattern is found not only in the Longobard area but also in the Povegliano section.

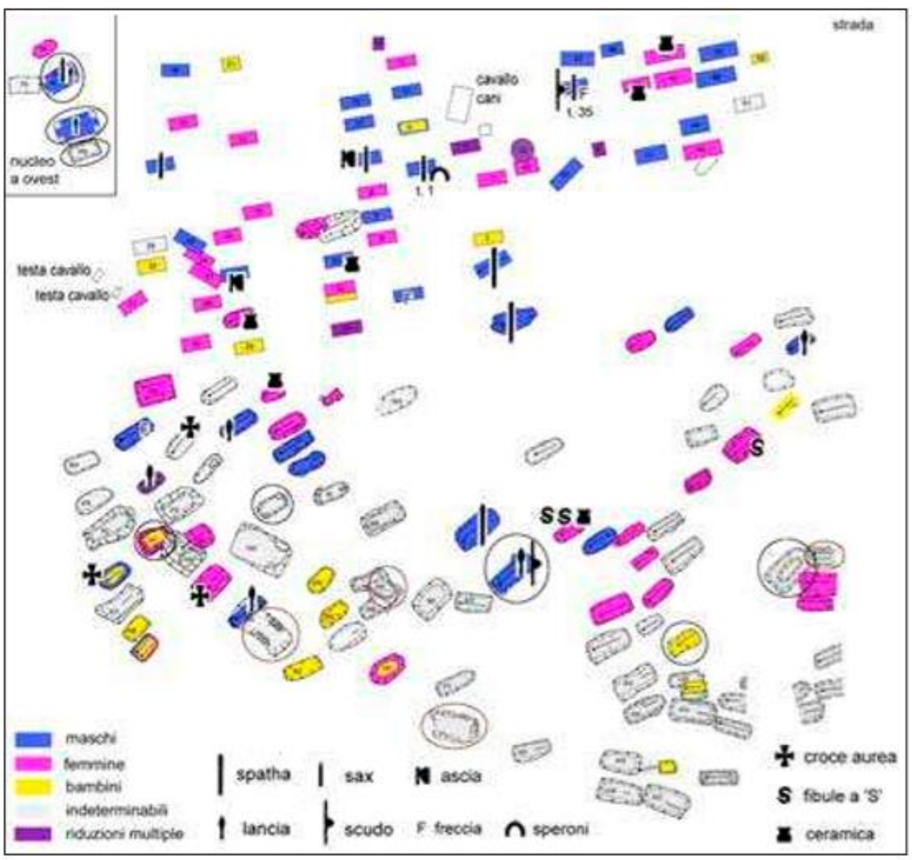



Figure (1.7). Map of the distribution of tombs in Povegliano Veronese (POV) (Vitali, *at al*., 2014; Brogiolo, *et al*., 2017)

From the examination of the typology of tombs and artifacts found, it was concluded that the necropolis began with a generation of immigrants and saw continuity in use until the end of the VI century or the early decade of the VIII century (Giostra, 2017). Based on data from the Soprintendenza Archeologica del Veneto between 1985 - 1993 explains that the number of tombs found in Povegliano Veronese is at least one hundred and forty-five graves and the outside there are also five graves (fig. 1.7) in the burial area of 180.000 square meters where there are also isolated tombs which are thought to be the possibility of the exclusivity of individuals buried in the area (Giostra, 2017). The layout of the tomb is partly arranged with the orientation towards north-south, the tomb of the eastern sector is partly arranged in the west- east direction. Besides that, sometimes there are overlapping tombs that are not aligned with the previous tomb with a North / West-South / East orientation, with some exceptions or perpendicular to the first, the fact also shows that there is a burial that is superimposed on the previous tomb.

### 1.2.2. Selvicciola (SLV)

The Selvicciola (SLV) site is located in the territory of the province of Viterbo, 115 km from Rome in Lazio of Italy. This is a post-classical burial site which is about 43 km from city center of Viterbo ad borders with province of Grosseto in the north with a coordinate point of 42°33'43.6"N 11°34'59.0"E. This region is quite interesting with the presence of strong historical evidence starting from the Neolithic necropolis, the Roman villa, the early middle ages necropolis.

The Roman villa located between the Canino Mountains and Fosso dello Strozzavolpe was unintentionally revealed in 1981 during agricultural work. Subsequently in 1982, under the direction of the Responsabile della supervisione archeologica dell'Etrusia meridionale by volunteers of the Roman Archaeological Group and the Italian Archaeological Group, a systematic excavation was carried out and revealed the existence of the vast Roman rural complex and the

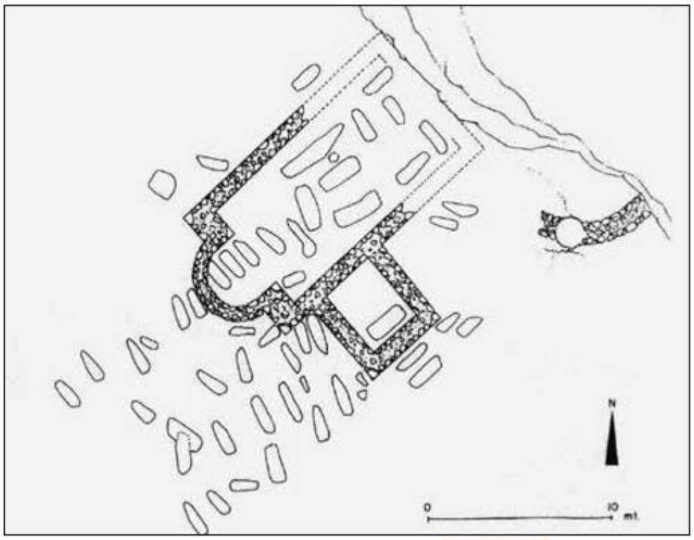
Lombard necropolis dated between the half of the IV century to the beginning of the VIII century (Gazzetti, 1995; Incitti, 1997).


Figure 1.8


Figure 1.9

Figure (1.8). The location of La Selvicciola area in map in red triangle symbol Figure (1.9). The map of La Selvicciola Site in the phase Longobarda around VII – VIII century D.C (Gazzetti, 1995)

The excavation was stopped in 1990 and then resumed in 2005. Based on the results of reconstruction, the villa is difficult to read due to overlapping of several interventions, the residential part extends around the peristyle of the rectangle and rests on the top level of the travertine bench and on the second level of the travertine bench. The processing area is arranged around the atrium with tanks - including olive oil mills and associated *doliarium sites* and other parts are continuously researched to provide an overall explanation[4].



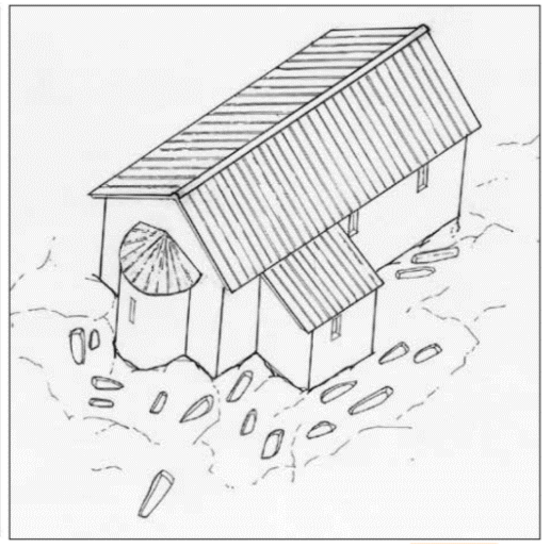


Figure (1.10 and 1.11). A description of the findings around the Selvicciola church and their form of reconstruction (drawn by Gasseau inPatera,, 2008)

In the funeral area there is a Christian church dating from the 5th - 6th century AD (Incitti, 1997). Furthermore, the burial church (symbol A in fig. 1.9) was founded in the middle of the 7th century (figures 1.10 and 1.11; Incitti, 1997; Patera, 2008) on the part of the most ancient core of the burial ground with grave holes covered with tiles placed with "alla cappuccina" which continued to be widely developed until the 8th century which still included around 200 burial holes (Gazzetti, 1995). Inside of the church was found pieces of painted plaster and marble and crust plates which were probably decorated with polychrome mosaics, especially in the presbyteral area which had a cover of marble slabs and fresco decoration (Patera, 2008).

Furthermore, there are some skeletal findings in the tomb of the Longobard phase which are estimated to be around VII - VII century. Some parts are considered post-classical burials

[4] Unpublished report from I Risultati Dei Campi di Ricerce Dei Gruppi Archeologici D'Italia https://gruppiarcheologici.org

obviously originating from Longobard as well as some previous burials which are thought to be most likely Roman, with a total of 85 graves; 19 double graves and 4 double graves from excavation (Micarelli, et al., 2019).

# CHAPTER TWO

# 2. Material Background

## 2.1. Teeth Genesis

Teeth are hard material found in the mouths of humans and many vertebrates. Having a variety of shapes and structures that may have many functions for the survival of living things. In general, the teeth function as tools for grabbing and feeding, but some animals especially carnivores, function as personal protection (attack and defense) and as weapons to immobilize prey (reference).

Teeth have a strong relationship with the type of food in animals in distinguishing food consumed. Herbivorous animals have many strong molars to feed their food such as the grass on cows. While carnivores tend to have sharp canines and some animals do not have molars because they are used to kill prey and grab food and are swallowed directly and omnivorous creatures certainly have completed and complex teeth to support their function as meat and plant eaters. Furthermore, Paleontologists often use teeth as material to identify the type of fossil found and some scientists do comparative analysis of teeth to get a picture of evolutionary behavior during the development of a species under study. In mammals, teeth attach to the jaw by supporting connective tissue, which consists of cementum, periodontal ligament (PDL), and alveolar bone, which provides sufficient flexibility to resist the strength of mastication while in humans and most mammals, limited tooth succession still occurs, one cannot compensate for tooth loss but to provide growth in the face and jaw (Nanci, 2017).

### 2.1.1. Morphology and Anatomy

The main elements in the teeth consist of crowns and roots. These two parts are the most important part in tooth anatomy. Between them there is a barrier called cervical margin which clinically shows the part of the tooth visible in the oral cavity although the teeth vary greatly in shape and size histologically the teeth are similar (Nanci, 2017). Anatomically teeth have differences with one another, but in terms of the process of growth have in common. Each tooth grows successively from the bud, cup and bell stages and at the bell stage an enamel and dentin are formed and the crown is formed and mineralized roots begin to form (Avery and Chiego, 2006). Next, the dental support network; cementum, periodontal ligament, and alveolar bone grow. This occurs in incisors with one root, premolars with multiple roots or molar with multiple roots and then a complete tooth crown erupts into the oral cavity (Avery and Chiego, 2006). Root growth and sementogenesis are continued until the teeth function and are supported by a perfectly growing tooth structure.

Teeth consist of hard, inert, acellular enamel formed by epithelial cells and supported by dentin connective tissue that is less mineralized, tougher, and vital, which is formed and supported by dental pulp, soft connective tissue (Joiner, 2007; Nancy 2017; Lynnerup and Klaus, 2019). On the surface of the crown there are extra mounds especially in the premolars and molars known as cups or folds which are covered by lophs. The outer layer of teeth is a hard enamel which in the next layer is called dentine which contains nerve tissue and blood vessels (fig. 2.1).

The next layer is in the form of dental cavity or called pulp which is corona and radix. Furthermore, the column which referred to as the neck of a tooth is the part of the tooth that is inside the tip of the corona that is in contact with the gum which is usually a divider between the root and crown of the tooth. While the point between the crown and the root is called the cervix. Radix is the lowest part of a tooth that is embedded in the jaw bone which is intertwined by dental cement which functions as a dental glue on the jawbone.

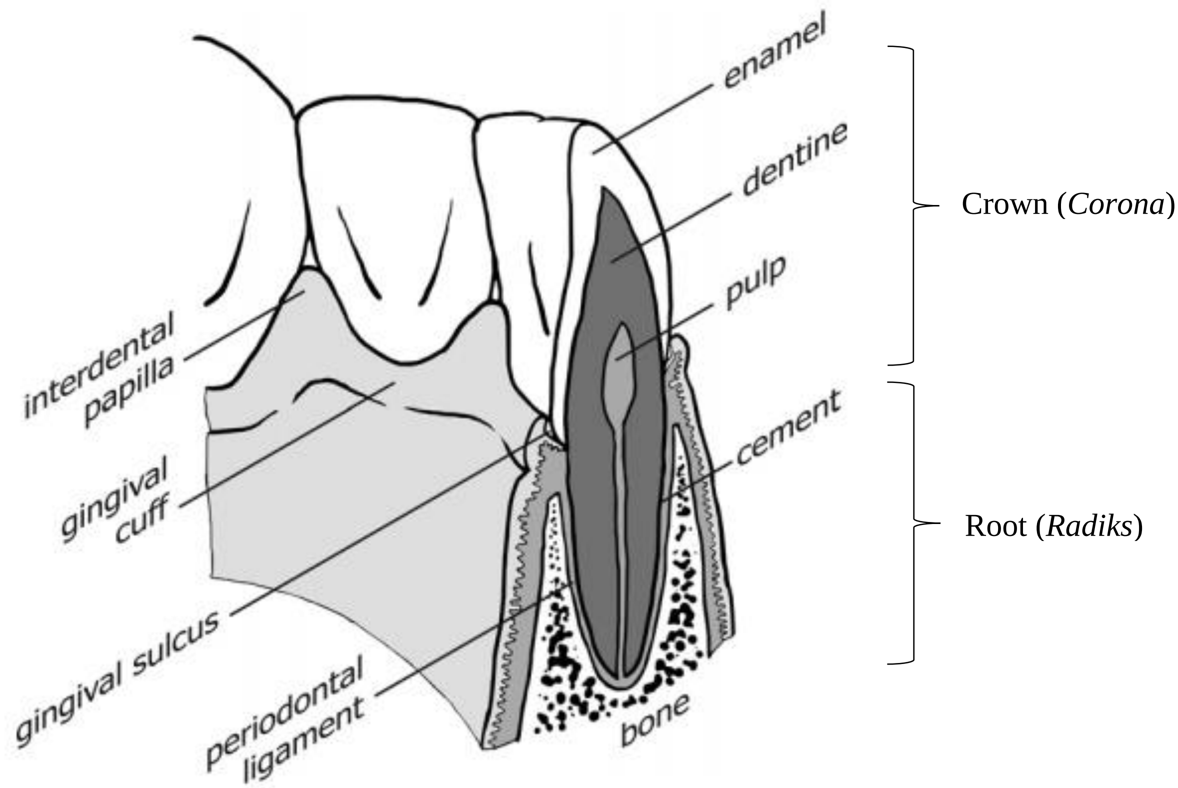



Figure (2.1). Anatomy of the tooth and periodontium (slight modifications and additional information from Hilson, 2005, page. 9).

In conducting research on human material in the form of bones and teeth, anatomical terminology is agreed upon from anatomists as well as physical anthropologists and other disciplines in the form of a concise and precise nomenclature that enables clear equality of perception between fellow researchers studying skeletal material. It refers to the movement and relative location of parts of the skeleton in osteology. In terms of human dental material, it has been given a clear naming of tooth parts by White et al., (2011) namely; mesial, distal, lingual, labial, buccal, interproximal, occlusal, apical, cervical, incisal, mesiodistal, buccolingual and labiolingual sections. Explanation can be seen in fig. 2.2 as follows:

a. mesial is the proximal surface closest to the midline in the quadrant division of the teeth both in the maxilla and mandibular while distal is the distance furthest surface proximal to the midline.

b. lingual: the surface that touches the tongue (Anterior and Posterior) from the inside and the labial is the surface of the anterior teeth facing the lips.

c. facial: the surface of the teeth closest to the cheeks or lips (most of which are part of the anterior teeth).

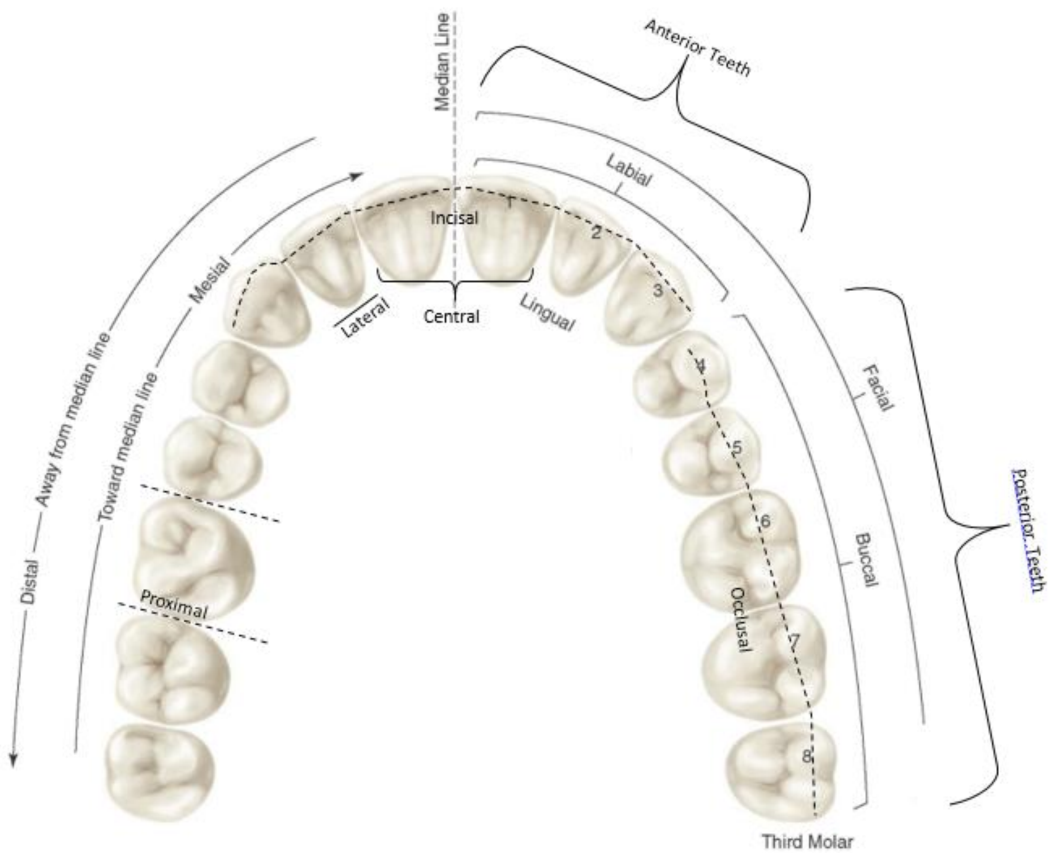



Figure (2.2). Parts of the teeth used in describing and identifying teeth (edited from www.what-when-how.com)

d. Buccal: posterior tooth surface close to the cheek (usually reserved for premolars and molars).

e. The surface of the teeth in the anterior part of the teeth is called the incisal (the biting or edge of the incisors) while the occlusal part of the posterior teeth.
f. Interproximal: The area of a tooth that is in contact with adjacent teeth in the same jaw.

In addition, in describing the teeth there are additional parts to clarify the individual teeth. Human teeth consist of many ridges, ridges, depressions, and grooves. The section is a peak with different heights that can be observed on the occlusal surface of the premolar and molar and on the incisal edge of the canine. The naming is adapted to the 4 sides of individual teeth; mesial, distal, lingual and labial. For incisors only have a flat surface on the incisal while the canine has a difference between the mesial and distal sides and among them there are pits. Both the incisor and canine have a protruding part on the lingual side called the cingulum with a slightly convex shape located on the cervical line (the border between the crown and the root).

In the pre-molar teeth and in the molar the naming is distinguished between the maxilla and the mandibular. Premolar teeth (maxilla) have 2 cups that have almost the same size but on the mandibular just the opposite. The grooves (lines) on different surfaces where the maxilla is irregular in the molar with teeth tend to be rhombic with three or four major cusps while the mandibular is more regular and shape more square or rectangular which usually has four or five major cusps. The cups on the maxillary molar teeth begin with the lingual part in succession (fig. 2.4): mesiolingual (protocone), mesiobuccal (paracone), distobuccal (metacone) and distolingual (hypocone) and in the mandibular usually there are 5 cups usually M1: mesiolingual (paracone), distobuccal (metacone) and distolingual (hypocone) and in the mandibular usually there are 5 cups usually M1: mesiolingual (metaconid), mesobobcal (metacone) and distolingual (hypocone) protoconid), distobuccal (hypoconid) distolingual (entoconid) and distal (hypoconulid).

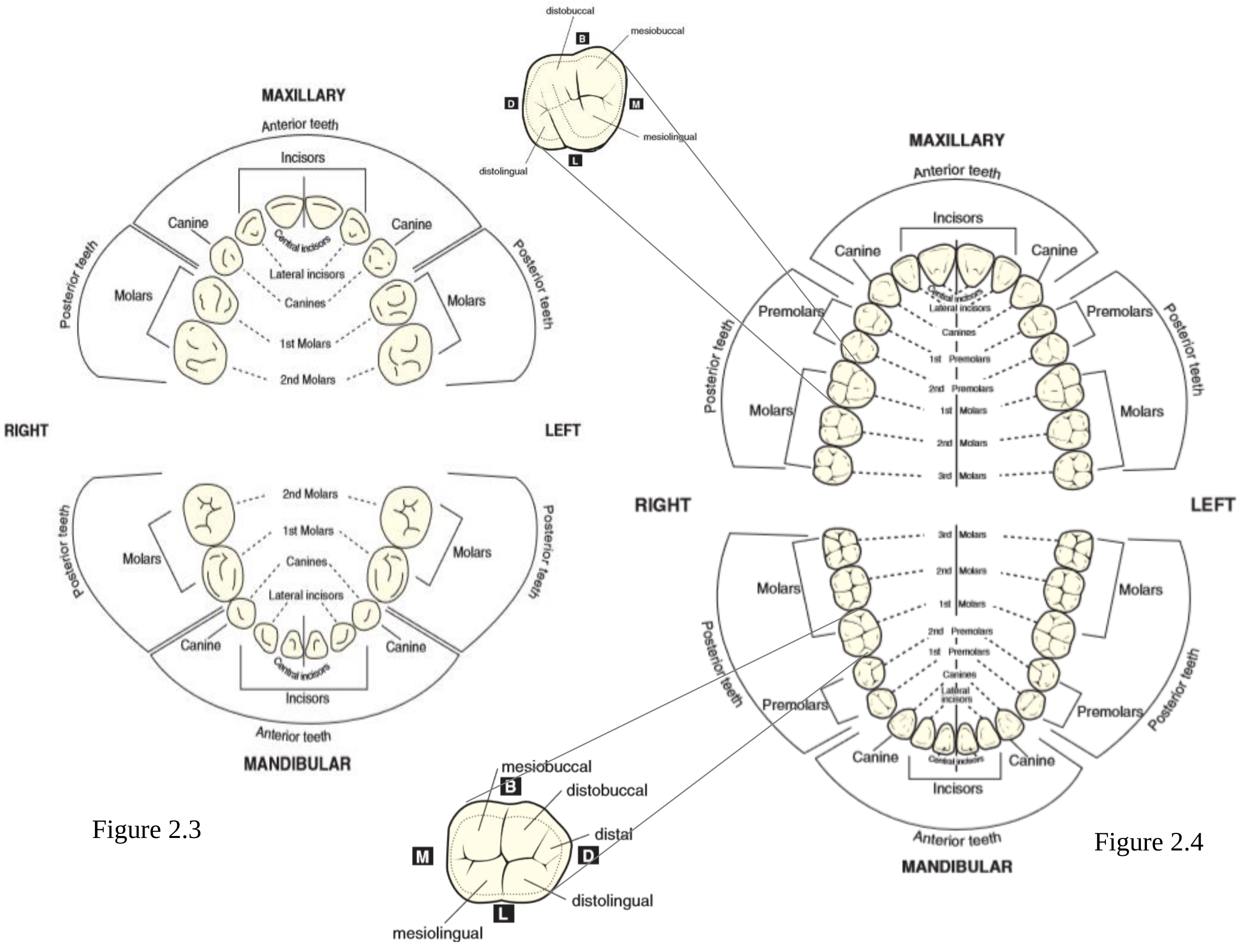



Figure 2.3

Figure 2.4

Figure (2.3). Primary teeth (deciduous) and Figure (2.4). Permanent teeth and occlusal view of first molar (M1) in maxilla and mandibular right side (slightly modifications from (Scheid, 2012, page 5 and 6).

Human teeth are defined as heterodonts, consisting of various types, or classes, of teeth to perform different functions in the mastication process (Fuller *et al*., 1999). Based on the period of growth of teeth in humans has 20 deciduous (primary) teeth and 32 permanent teeth (fig. 2.3 and 2.4) that develop from the interaction of epithelial cells in the oral cavity and mesenchymal cells from childhood to adulthood. Complete primary teeth are usually present in children from the age of two to six years, the twenty teeth are found in all primary teeth; ten in the maxillary arch and ten in the mandibular with details Incisor 2/2 Canine 1/1 Molar 2/2; 5 upper and 5 lower teeth in each quadrant; 20 teeth in all (Scheid, 2012).

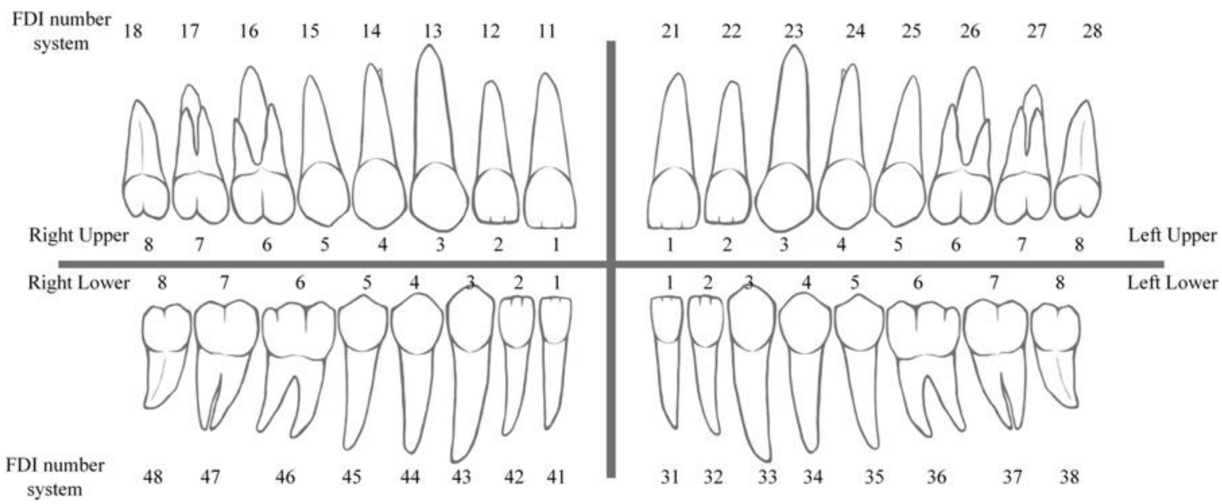



Figure (2.5). Federation Dentaire Internationale (FDI) teeth numbering system: 11–18 = right upper 1–8, 21–28 = left upper 1–8, 31–38 = left lower 1–8, 41–48 = right lower 1–8; 1. Central incisor, 2. Lateral incisor, 3. Canine, 4. First premolar, 5. Second premolar, 6. First molar, 7. Second molar, 8. Third molar (Chen, *et al*., 2019)

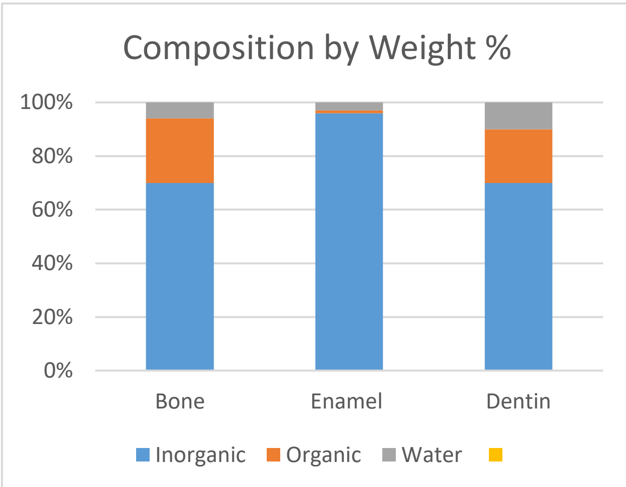
While complete permanent teeth in adults consists of 32 teeth with 16 details in the maxilla and mandible with 8 teeth divided in each quadrant. The teeth are divided into four classes in terms of form and function; incisors (I), canines (C), premolars (PM) and molars (M). Each quadrant in a row 2 Incisor, 1 Canine, 2 Pre-Molar and 3 Molar with formula I 2/2, C 1/1, PM 2/2, M 3/3. Although it is sometimes found in archaeological material samples the backmost molar teeth (3rd molar) are usually still hidden in the lower part of the bone which is now called "wisdom teeth" from dentistry.

### 2.1.2. Structure and Composition

Dental crowns have a hard and shiny enamel coating as well as the most mineralized human body tissue. In addition, the crown is also coated with a layer of tissue such as bone called cement. On the inside there is a pulp chamber in which there is a soft tissue pulp that includes dentine cells, blood and nerve supply (Hillson, 2005). Hard, inert, acellular enamel formed by epithelial cells and supported by dentin, which is less mineral, more resilient, and vital, formed and supported by dental pulp, soft connective tissue. The formation of enamel or amelogenesis has two stages of formation. First, Enamel is formed which only partially mineralizes about 30%, when the organic matrix is broken and removed then the crystal grows wider until the full thickness with the enamel layer reaches more than 96% mineral content (Nanci, 2017).

In addition to collagen content, the organic component of dental tissue in the form of fibrous protein, is also found in dentin, cement, and bone. There are amorphous substances, known as "ground subtances" which may be in the context of cells or serum and organic acids associated with mineralization, these include lipids, peptides, glycoproteins, and glycosaminoglycans (Elliott, 1997). Finally, there is a component of the enamel protein that forms about 30% of the teeth with an amino acid proline histidine, leucine and glutamine which may eventually form 10% in the matrix and are mixed with other components (Hilson, 2014).

As the hardest biological substance, with mature enamel having nearly 97% higher mineral composition and not reshaping (Goodman and Rose, 1990, Hillson, 2014). The breakdown of composition is 96% inorganic material and 4% organic matter and water and in dentin there is inorganic material representing 70% by weight which inorganic material mainly consists of calcium phosphate which is idealized as hexagonal calcium hydroxyapatite [Ca $(PO_4)$ 6 $(OH)_2$] (Lucas, 2004; Pasteris et al., 2008; Ramakrishnaiah et al., 2015; de Dios Teruel et al., 2015). Furthermore, although most of the inorganic components are apatite, a proportion of other forms are also found. Some calcium phosphate crystals, including whitlockite, β-Ca3 $(PO_4)_2$, brushite $CaHPO_4.2H_2O$ and octa calcium phosphate $Ca_8$ $(HPO_4)_2$ $(PO_4)_4$ $H_2O$ (Hilson, 2014). Although teeth and bones are similarly formed from biomineralized material derived from inorganic components, which are usually nanocrystalline, and organic components, especially proteins. Chemically-structurally bone consists of about 45-70% by weight of minerals, 10% by weight of water, and the remaining collagen plus a small portion of non-collagen protein (Rogers and Zioupos 1999; Skinner, 2005).



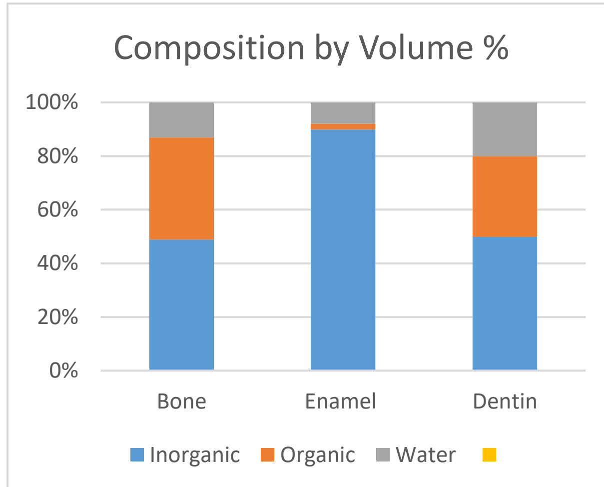



Chart (2.1) and (2.2). Biomineralized nanocomposite in human which represent by weight (wt.%) and volume (vol.%) with density (g/cm$^3$) bone 2.35, enamel 2.92 and dentin 2.51 (This data was taken from Skinner, 2005 with modifications to different presentation models).

The main components of apatite mineralized tissue in bone, dentin, and enamel are inorganic (mineral), organic (collagen) and water material. From the data on charts 2.1 and 2.2 it can be concluded that the composition of the enamel has a significantly different number of percentages compared to bone and dentin which is dominated by inorganic material 90% by volume and the remaining 96% by weight in the form of water and organic which is only 2% and 1%. While the material in bone and dentin have the same percentage amount of mineral material (inorganic) based on wt% of 70% and a little bit different by vol.% where the dentin more 1% (49% and 50%). Lastly, organic material is dominated by bone both in terms of weight and volume, respectively 24%, 20% and 38%, 30% while the percentage of water is actually more on the dentin material.

## 2.2. Diagenesis of Teeth

In the archeological context one of the reasons teeth were chosen as research material is because they have high resistance to the destructive effects of decay and external agents. Also, the presence of high hydroxyapatite content is present in tooth enamel which is considered the hardest tissue of the human body, a material that allows analysis of long periods of time after individual death (Ishida et al., 2019). Apart from occlusal wear and abrasion, the growth can be recorded throughout the life of an individual because it contains high minerals that are not too affected by degradation as archeological remains (Gamble et al., 2017).

Although resistant to degradation and the destructive effects of external agents, several studies have shown the existence of large external influences. Outside challenges that can affect damage to apatite include; leaching in pervasive ground water through the matrix of burial, adsorption and replacement of fluorine from ground water, bone cremation, porosity, size, and structure of the buried bone or tooth itself (Hilson, 2014). Despite the few case examples in various archeological and geological contexts, apatite seems to have survived very well. Tooth from cremation or skeleton that burns at a certain temperature combustion, for example. With the color change in the fire at a certain temperature allows some organic material to disappear. The underlying thing is with a change from apatite to *whitlockite* between 200 and 600 ◦C (Sakae et al., 1997).

Some characteristics of changes that occur in the teeth, especially related to pathology in the archeological context. Most often, deformed teeth, retained for life except for wear, result from a disruption in tooth formation during childhood (Katzenberg and Grauer, 2018). These changes take the form of; caries, abscesses, Antemortem Tooth Loss (AMTL), Linear Enamel Hypoplasia (LEH), dental calculus (mineralized plaque on the tooth surface) and periodontal disease are inflammatory processes that involve periodontal tissue loss and alveolar bone porosity (Masotti et al., 2019). Special changes in hard tooth tissue (enamel) are usually found including amelogenesis imperfect, enamel hypoplasia, enamel opacities and dental fluorosis in the form of permanent *hypomineralization* of enamel in the form of small spots on teeth while in dentin and enamel usually *odontodysplasia*, rickets (usually lacking vitamin D in the form of permanent hypomineralization of enamel in the form of small spots on teeth while in dentin and enamel *odontodysplasia*, rickets when tooth growth) and Segmental *odontomaxillary* dysplasia (Slootweg, 2007).

Morphological changes and diagenesis in teeth are phenomena after death including all processes that can affect the degradation and derimineralization of both inside and outside the soil, changes in hard tissue spreading from natural surfaces, including periosteal and endosteal bone surfaces, and peripulma, radicular and coronal tooth surfaces (Bell et al., 1991). Research on cementum can also provide a chronology of individual metal exposure and diagenesis that may occur because it is thought to display an annual growth ring to distinguish endogenous diagenetic deposits in the metal content of cementum rings (Martin et al., 2007).

Research on dental caries in the population of the Russian settlers and non-agriculturalist indigenous Siberian people who lived together in western Siberia from the 16-19th century showed a clear correlation that farmers who ate carbohydrate-rich foods would have high rates of dental caries and AMTL (*ante-mortem* tooth loss) which is higher than hunter-gatherers (Lee et al., 2019) including C3 plants that affect environmental and socio-political change as a cause of caries (Cheung et al., 2019). Dental caries is also assumed to provide a gender position in society. A strong relationship between increased estrogen production during pregnancy and decreased salivary flow is a possible cause of high rates of caries in women, which differs from the traditional view of sexual division of labor which results in uneven access to cariogenic foods (Carvalho et al., 2019). The results of excavation from 12 South American archeological sites show the truth from the assumption. The research focus on caries, ante mortem, deep caries, and enamel hypoplasia, the result proof that the availability of micronutrients in society influences caries experience in pregnant women, as well as other cultural factors in the community plays an important role in oral health. Therefore, changes in dietary habits or dietary patterns have a very strong association with dental caries found in a population (Larsen, 2015; Nicklisch et al., 2016; Da-Gloria et al., 2017; Šlaus et al., 2018).

In addition to caries, Antemortem Tooth Loss (AMTL), Linear Enamel Hypoplasia (LEH), abscesses, dental calculus and dental erosion are important parts in archaeological dental research. Dental research in the Icelandic Sagas population points out that the cause of tooth erosion in the population is not solely due to food but also to food processing. Alleged consumption of acidic beverages and foods other than the coarse and rough diet, played a significant role in the dental erosion seen in ancient Icelanders (Richter and Eliasson, 2016). Other results suggest that significant sex differences in the diet of the population as an example of older women may have lower access to protein compared to men resulting in differences in abscesses, cariers and alveolar resorption and tooth wear in the gender, especially from the results of the study Vlach population (Adamić and Šlaus, 2017). In addition, for instance, tooth wear and abrasion on the vestibular surface of teeth are caused by the existence of a certain culture in a society that uses its teeth as its professionalization, a woman from the city of Mendes in ancient Egypt (Lovell and Palichuk, 2019), and the implications of a strong cultural and biological continuity for a population (De Groote et al., 2018). From the results of the above explanation it can be concluded that the cause of changes both chemically and physically in teeth in the context of pathology is caused by food, eating habits and food processing as the main causes and the presence of certain cultural behaviors in society also affect teeth in a population of the past.

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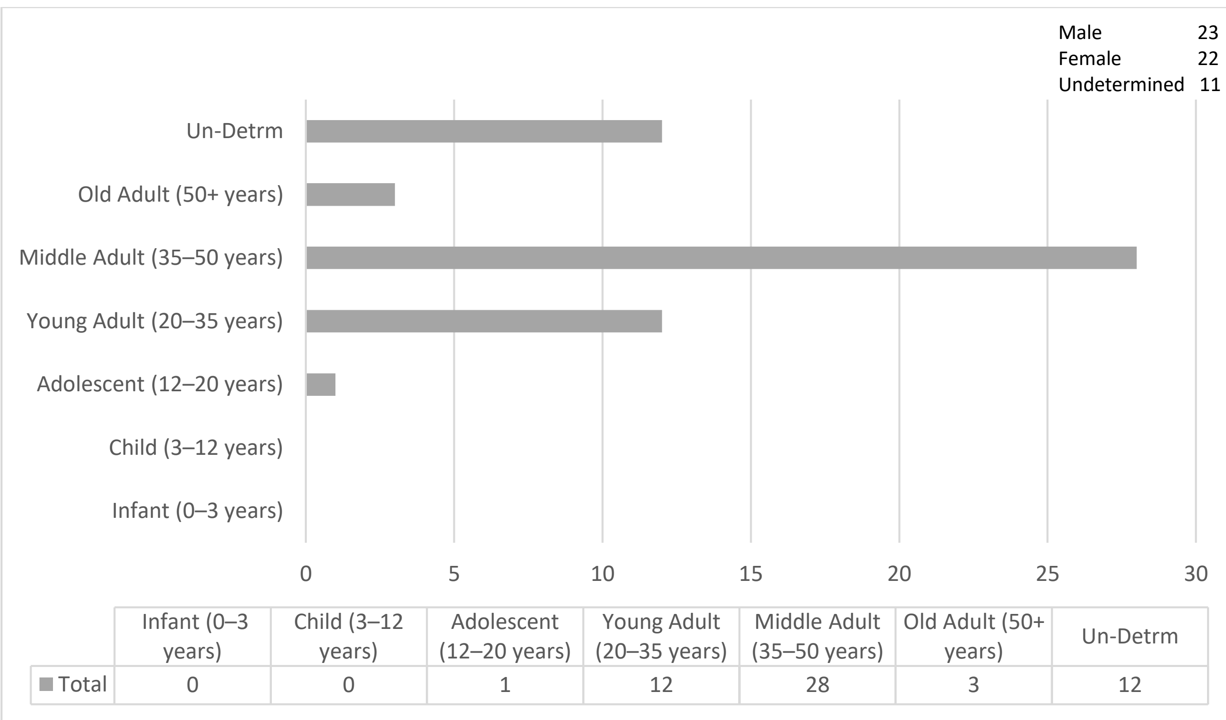
# CHAPTER THREE

# 3. Material and Methods

## 3.1. Material Research

### 3.1.1. Populations

In this study the research material was taken from skeletal remains originating from the classic and post-classic period populations in Italy (IV - VIII AD) of the Povegliano Veronese (POV) and La Selvicciola (SLV) sites stored at the Museum of Anthropology "Giuseppe Sergi" University of Rome La Sapienza. Data from the POV site total population of 56 individuals with details of 23 males and 22 females and 11 of undetermined sex. While from the SLV site the total population of 120 individuals consists of 29 males, 14 females and 77 undetermined of sex.




| | Infant (0–3 years) | Child (3–12 years) | Adolescent (12–20 years) | Young Adult (20–35 years) | Middle Adult (35–50 years) | Old Adult (50+ years) | Un-Detrm |
|---|---|---|---|---|---|---|---|
| Total | 0 | 0 | 1 | 12 | 28 | 3 | 12 |

Chart 3.1. Population from Povegliano Veronese Populations

Age of death estimates on samples based on the White, et al (2011) classification obtained data from the POV website; adolescent (12-20 years) 2 individuals, young adults (20–35 years) 24 individuals, Middle Adult (35–50 years) 56 individuals, old adult (50+ years) 6 individuals and undetermined 24 individuals. From data chart 3.1 above the number of women and men is almost the same in the population in the POV of 23 and 22 individuals and the rest are undetermined 11 individuals. Based on the age of death, it is dominated by middle-adult aged 35-50 years, then followed by young adult and undetermined with 12 individuals respectively. Finally, there are no samples from child and infant's classes.

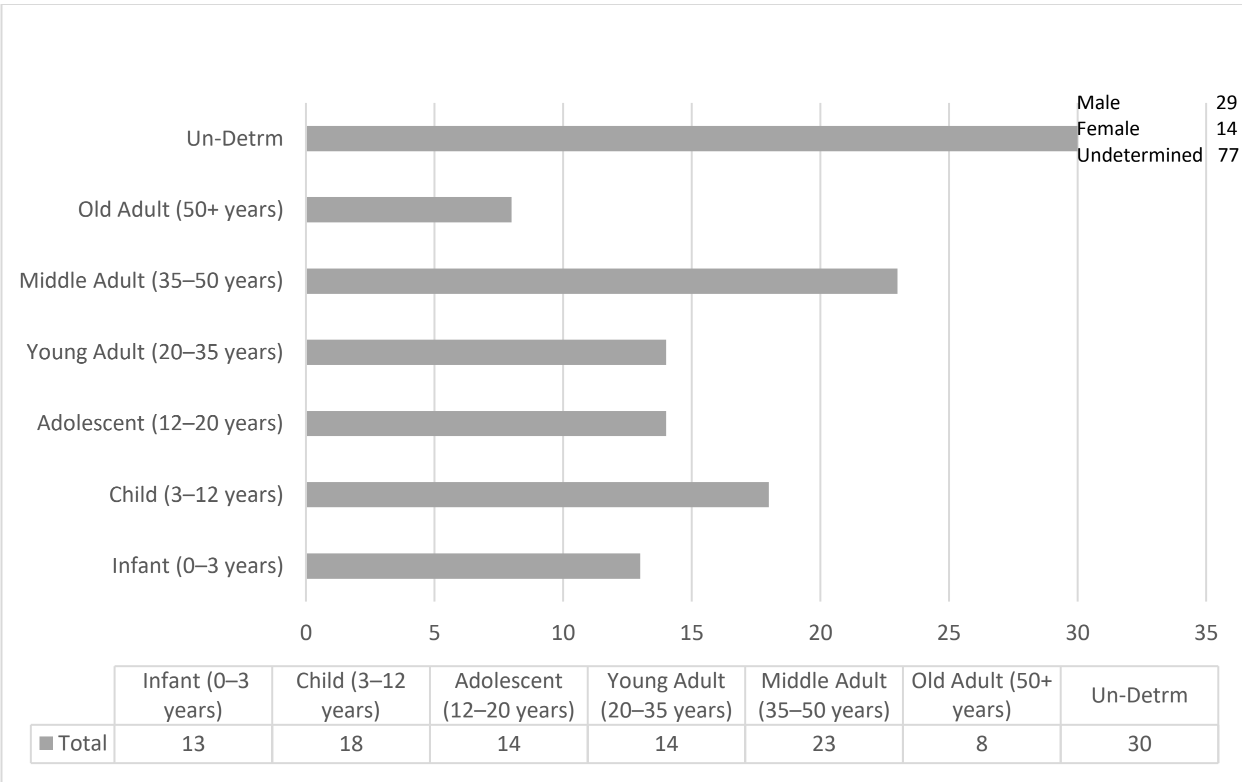



Chart 3.2. Population from La Selvicciola Populations

Population data from SLV sites tend to be complete from all age classifications with details; infant (0–3 years) 26, Child (3–12 years) 36, Adolescent 28, young adult 28, middle adult 46, old adult 16 and undetermined 60 individuals. Chart 3.2 above shows a sample of the population of the Selvicciola site can be found in all age of death classifications. Even though undetermined became the highest number in the sample, it was only 7 individuals with middle adults as the second largest. Then followed by 18 individual child classes. Young adult and adolescent individuals have the same number of individuals and only differ from one individual with infant and individuals 50+ years and above only 8 individuals as the least.

### 3.1.2. Teeth

The teeth can be divided based on growth between deciduous and permanent. In the following chart (3.3) there is the number of teeth for each individual from the two populations of Povegliano Veronese and Selvicciola. Here, the skeletons were classified among; individuals with only deciduous teeth, individuals with deciduous teeth and growing teeth in the bone, individuals with deciduous and permanent teeth and the last ones with exclusively permanent teeth. In addition, there is the sample with edentulous individuals, or skeletons "without teeth".

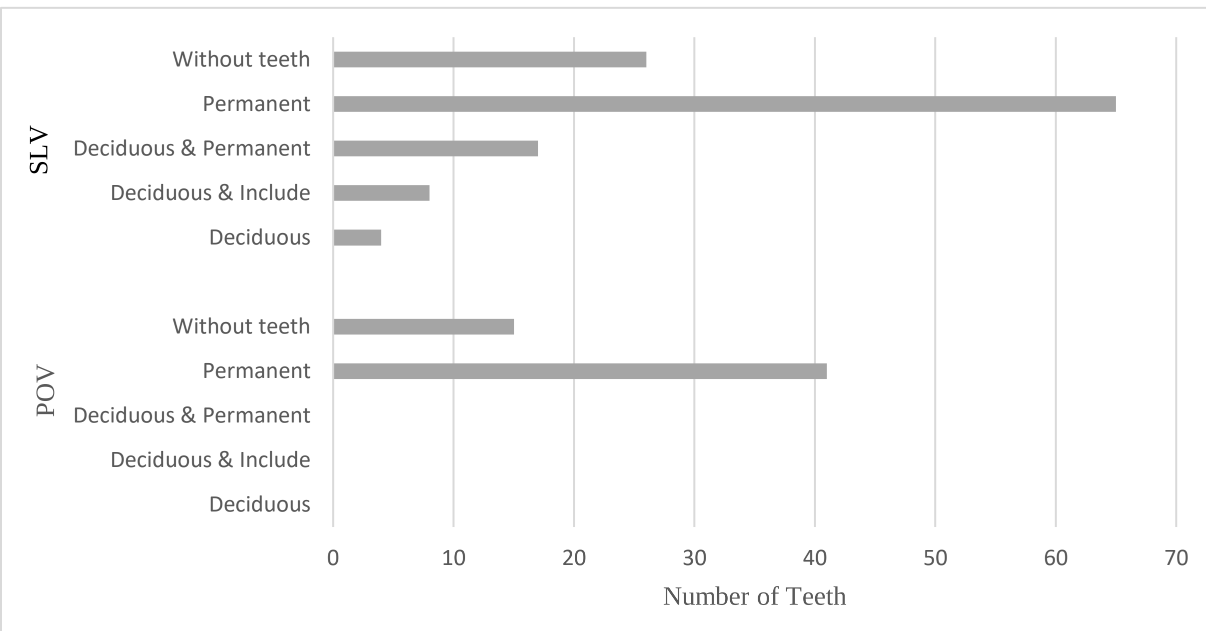



Chart 3.3. Classification of teeth from POV and SLV populations

The data above shows that from the POV population there are only 41 permanent teeth with the rest without teeth from 56 populations overall. While classification of SLV is more varied although it is dominated by permanent teeth population and without teeth, 65 and 26 individuals respectively. Furthermore, deciduous and permanent as many as 17 populations and deciduous include 8 populations. as the least is deciduous tooth population only 4 out of a total population of 120. This research will focus on Linear Enamel Hypoplasia (LEH) from several other types of dental defects such as defects in the form of pits or groves that are too deep although there are some defects in the form of grooves in the form of clear horizontal lines that can be included in the sample.

**3.2. Methods**

The method used in this study into some stages; description of the research sample in accordance with what is needed, assessment with macroscopic analysis to obtain the required data. This assumption uses bio archaeological standards in identifying LEH in the form of horizontal "lines" or "grooves" that are visually visible on the tooth enamel surface (Buikstra, 1994; Brickley and McKinley, 2004; Hassett, 2014). Finally, the analysis of data in statistics as the final stage to obtain information. Then the data is processed and analyzed to provide interpretation and explanation in accordance with the research objectives.

Identification is the initial stage in research to sort out the object of research with certain attributes in accordance with the standards to achieve research objectives. In this stage the teeth from the remaining skeletal remains are cleaned non-abrasively by using tweezers whose edges are sharp and also with a knife-eye (scalpel) and curved-type tweezers as well as small brushes (a kind of toothbrush). This is done to clean the dirt and material that covers the surface of the teeth such as the soil that is attached to the rest during excavation. Even Teaford and Oyen (1989), suggest the use of an oral irrigation device such as the "Water Pick" to be able to provide a clear picture of the teeth. But keep in mind so as not to damage the tooth enamel.

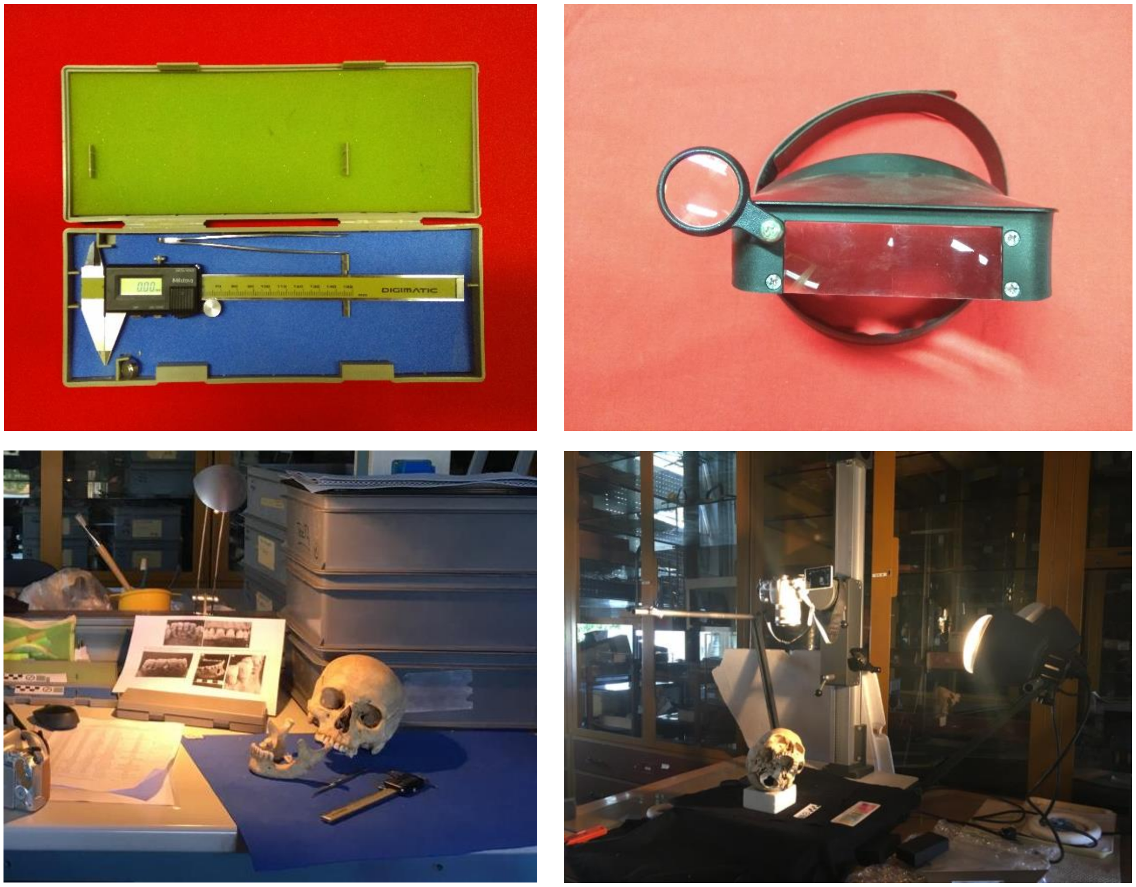


Photo 3.1 - 3.4 (left to right). 3.1). Digital Caliper and tweezer, 3.2). Magnifying Glasses, 3.3). Incandescent Lamps, 3.4). Shooting Place of Photos

Next stage is the description, a delineation of the material object under study as a data to be used at a later stage. In the description clearly described the condition of the sample in this case the human skeleton and teeth specifically as the focus of research. Furthermore, the sample attributes are recorded in a structured form including number, data and initial sample, site origin, gender and age. Tooth condition which includes four parts; deciduous, deciduous include, permanent and permanent deciduous. Each sample was taken using a DSLR camera (Canon EOS 200D 24,2 MP with Lens EF-S18-55 IS STM) to get a good resolution and magnification assisted with a shooting place that has lighting settings in the form of lights and camera placement sockets so that the image is not shaken and always focused. Photographing teeth is done to obtain a permanent record of surface phenomena (Goodman and Rose, 1990). The photo shoot is not only documentation that has enamel hypoplasia but also individuals who still have good teeth. Apart from being a documentation of this data it is also used as a note to compare existing data.

Assessment with macroscopic analysis. Samples that have been identified and described are then assessed one by one based on individual units. At this stage linear assessment of enamel hypoplasia (LEH) using standardized absolute Digimatic digital sliding calipers Mituloyo (Model NTD12-15 with 0-150mm) as a tool to measure the hypoplasia enamel that is placed on a dental crown (figg. 3.1 to 3.4). To support and facilitate measurement, magnifying glasses are used to see the presence of enamel hypolasia more clearly. It also uses bright enough lighting with proper lighting with a yellowish tint to see more clearly the sample being measured. Observation of defects on tooth surfaces is aided by lamp having a strong diffuse light source, and a second moving source that can be directed to provide oblique lighting with incandescent lighting better than fluorescent lighting from assessment experiences (Goodman and Rose, 1990).

The enamel hypoplastic measurement were taken calculating the distance between the cement-enamel junction (CEJ) and the line of LEH. The first line measured is the upper one. If present, the following lines are recorded as other episodic events (number two, number three, etc.). All the measurements were taken from mandible and maxilla, in sub-adults as well as in adults. Finally, to check the assessment blind tests were performed on some specimens. Tooth recording starts from incisor (I), canine (C), premolar (PM) and molar (M) both the left side and right side in the quadrant of tooth division by child classification (I1, I2, C, M1, M2), adult (I1, I2, C, PM3 (1), PM4 (2), M1, M2, M3). Age distribution between child and adult follows these age classes; children aged between 0-17 years while adults start 20 years (Buikstra and Ubelaker, 1994).

Measurement of defects in the crown provides raw data and analysis is needed to determine the age of the individual at the beginning of the development of the defect. The data must be analyzed by standardized methods to get the final results in accordance with the research objectives. Therefore, the last step is a statistical analysis using the formula Regression Equations for estimation of age at linear enamel hypoplasia formation (Goodman and Rose, 1990) (Table 3.1).

| | | Tooth | Formula | |
|---|---|---|---|---|
| ADULT | CHILD | I1 | Age = - (0, 454 x H) + 4.5 | **Maxillary Teeth** |
| | | 12 | Age = - (0, 402 x H) + 4.5 | |
| | | C | Age = - (0, 625 x H) + 6.0 | |
| | | PM1 | Age = - (0, 494 x H) + 6.0 | |
| | | PM2 | Age = - (0, 467 x H) + 6.0 | |
| | CHILD | M1 | Age = - (0, 448 x H) + 3.5 | |
| | | M2 | Age = - (0, 625 x H) + 7.5 | |
| ADULT | CHILD | I1 | Age = - (0, 460 x H) + 4.0 | **Mandibular Teeth** |
| | | 12 | Age = - (0, 417 x H) + 4.0 | |
| | | C | Age = - (0, 588 x H) + 6.5 | |
| | | PM1 | Age = - (0, 641 x H) + 6.0 | |
| | | PM2 | Age = - (0, 641 x H) + 7.0 | |
| | CHILD | M1 | Age = - (0, 449 x H) + 3.5 | |
| | | M2 | Age = - (0, 580 x H) + 7.0 | |

Information: Age in years = - (1/velocity) x H (line distance of LEH from CEJ)) + Age at crown completion

Table 3.1. Formula Regression Equations for estimation of age (slightly modify and add an information from Goodman and Rose, 1990)

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# CHAPTER FOUR

# 4. Result and Discussion

## 4.1. Result

### 4.1.1. Povegliano Veronese (POV)

Identification was carried out from all samples both from populations of the Povegliano Veronese (POV) site as well as the population of the Selvicciola (SLV) site. Table 4.1 shows that of 56 individuals in total POV population, 41% were identified as linear enamel hypoplasia. LEH was detected in young adults as many as 7 individuals, middle adults 14 individuals, the remaining 1 individual old adult with age 50+ and undetermined 1 individual. While in terms of sex, there are more females with 12 individuals, 9 males and 1 undetermined (table 4.2).

| Information | | | Age Classes | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Σ | | Infant (0–3 years) | | Child (3–12 years) | | Adolescent (12–20 years) | | Young Adult (20–35 years) | | Middle Adult (35–50 years) | | Old Adult (50+ years) | | Un-Detrm | |
| N | n | % | n | % | N | % | n | % | n | % | n | % | n | % | n | % |
| Population | 56 | 100 | 0 | 0 | 0 | 0 | 1 | 1.78 | 12 | 21.4 | 28 | 50 | 3 | 5.35 | 12 | 21.4 |
| Sample LEH | 23 | 41.0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 30.4 | 14 | 60 | 1 | 4.34 | 1 | 4.34 |
| Without LEH | 33 | 58.9 | 0 | 0 | 0 | 0 | 1 | 3.03 | 5 | 15.1 | 14 | 42.4 | 2 | 6.06 | 11 | 33.3 |

| Information | | | Sex | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Σ | | Male | | Female | | Un-Detr. | |
| N | N | % | n | % | n | % | n | % |
| Population | 56 | 100 | 23 | 41.0 | 22 | 39.2 | 11 | 19.6 |
| Sample LEH | 23 | 41.0 | 9 | 39.1 | 13 | 56.5 | 1 | 4.34 |
| Without LEH | 33 | 58.9 | 14 | 42.4 | 9 | 27.2 | 1 | 3.03 |

Table 4.1 and 4.2. Population number of linear enamel hypoplasia based on age and sex from Povegliano Veronese (POV) population.

There are about 58.9 % of individuals who do not have linear enamel hypoplasia (LEH) including 15 recorded individuals who have no teeth (table 4.3). With a difference of about 18% of the sample that has LEH. All 23 individuals identified by LEH were found on permanent teeth. This is consistent with individuals who are mostly from middle-adult classes between the ages of 35-50 years old and young adults with age ranges from 20 -35 years who certainly have permanent teeth.

| Information | | | Type of Teeth | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Σ | | Permanent | | Deciduous | | Deciduous & Include | | Deciduous &Permanent | | Without teeth | |
| N | n | % | n | % | n | % | n | % | n | % | n | % |
| Population | 56 | 100 | 41 | 73.2 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 26.7 |
| Sample LEH | 23 | 41.0 | 23 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Without LEH | 33 | 58.9 | 18 | 54.5 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 45.4 |

Table 4.3. Population number of linear enamel hypoplasia based on type of teeth from Povegliano Veronese (POV) population.

Photo 4.1. Enamel hypoplasia on the mandibular and maxillary from POV sample (sample no.14: 349)

Photo 4.2. Enamel hypoplasia on the mandibular and maxillary from POV sample (sample no.14: 349)

From the results of identification in the POV population sample, it was obtained that both the maxilla and mandibular LEH findings were mostly found in incisor teeth ($I^1$, $I^2$, $I_1$, $I_2$) and canine ($C^x{}_y$) on both on the left and right sides of the quadrant of the teeth. In the maxillary section LEH findings were found in each type of tooth even though of the many samples only one molar ($M^{3R}$). While the mandibular teeth are not found in the teeth in the posterior part, especially molar 1 and molar 3 and only found in the 2nd molar ($M_{2L}$).

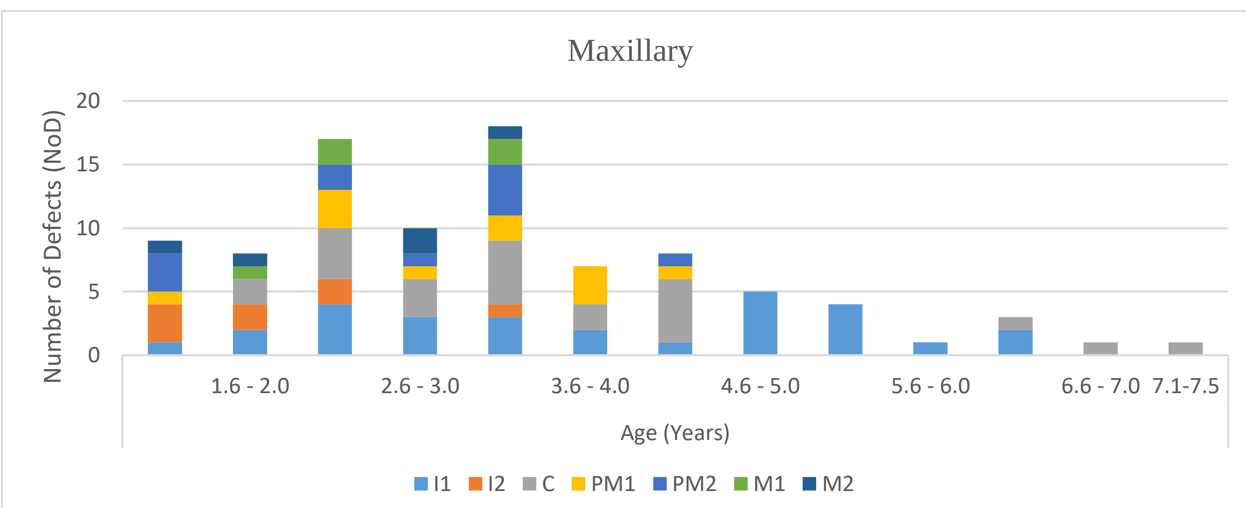


Chart 4.1. Number of defects from maxilla

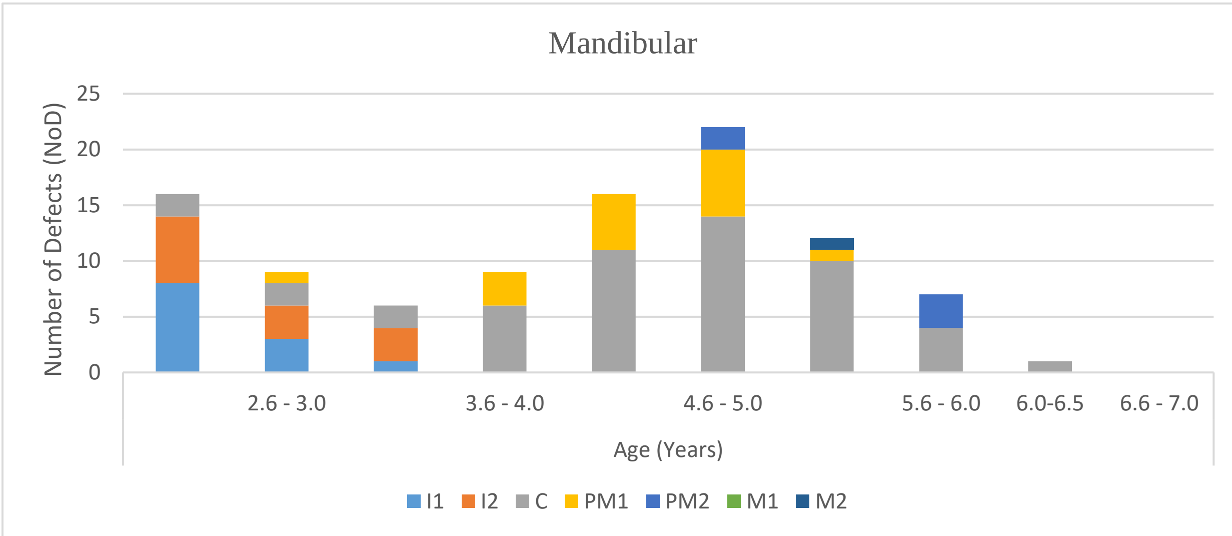


Chart 4.2. Number of defects mandibular

From the above chart 4.1 and 4.2, which describes the Number of Defects (NoD) and Age (years) composed of LEH from teeth incisor 1 (I1), Incisor 2 (I2), Canine (C), Premolar 1 (PM1) Premolar 2 (PM2) Molar 1 (M) and Molar 2 (M2). The incidence of LEH in maxilla begins at the age of 1.1-1.5 years and is still found at age 7.1-7.5 years. While in the mandibular begins at the age of 2.1-2.5 years and finally at the age of 6.1-6.5 years. The highest number of defects (NoD) in mandibular teeth at age 4.6-5.0 years and age 3.1-3.5 in the maxilla section with the number 18 NoD followed by 17 NoD at age 2.1-2.5 in maxilla and age 2.0-2.5 also 4.1-4.5 respectively 17 NoD on mandibular. The lowest defects were consecutively at ages 5.1-5.5, 6.6-7.0, and 7.1-7.5 in maxilla and 6.1-6.5 in mandibular all 1 NoD.

According to the data (chart 4.3), LEH's chronological distribution revealed two peaks of defects: at age 2.1-2.5 years (more clearly) and 4.6-5.0 years. The LEH chronology starts at age 1.0-1.5 with NoD high enough compared to the age afterwards before reaching its peak in the third period and only ends at age 7.1-7.5 with a fairly low amount. LEH chronological distribution is quite fluctuating since its appearance in the first year, after reaching the highest peak in the third year and then up and down until the age of 3.6-4.0. Until it ends stagnant at age 6.6-7.0 and 7.1-7.5.

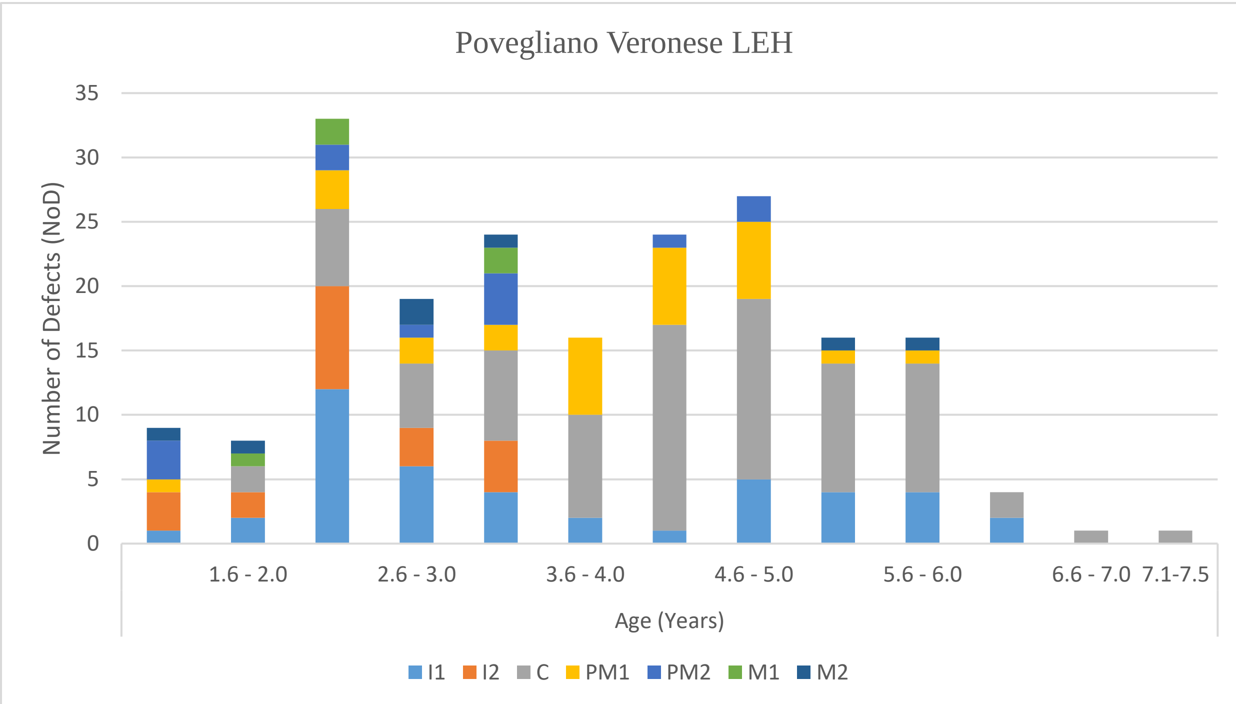


Chart 4.3. LEH age at death distribution of samples from populations of Poveglia Veronese (POV)

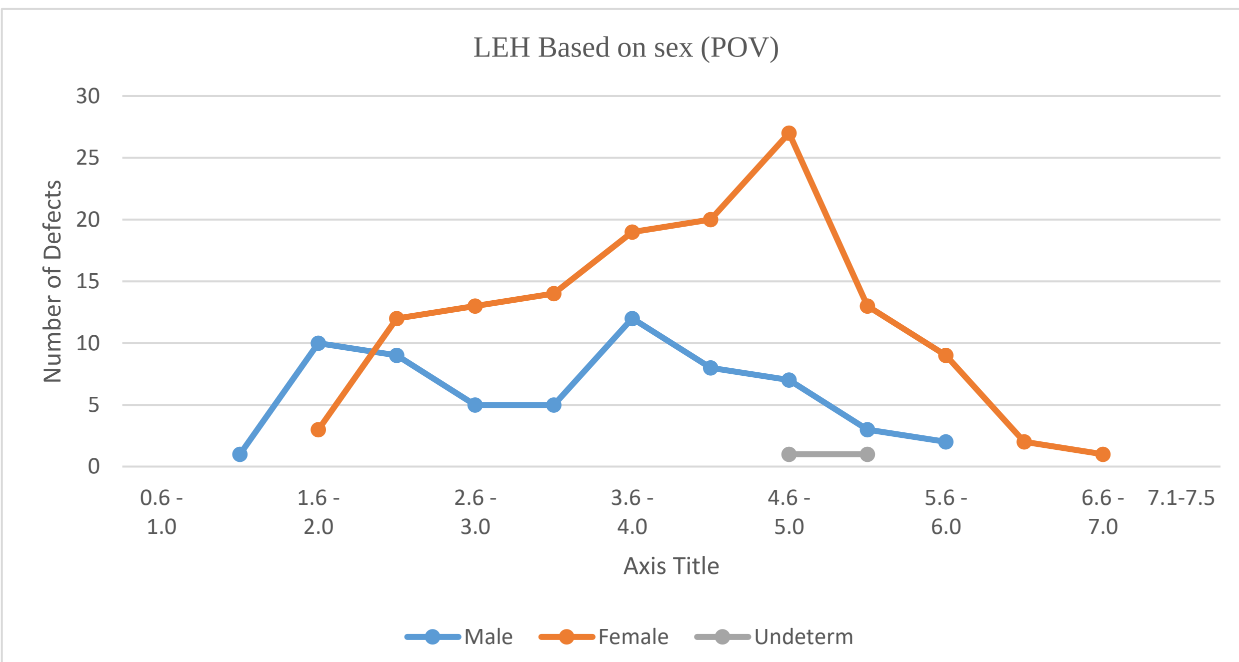


Chart 4.4. LEH age at death distribution based on sex

The distribution of LEH based on sex (chart 4.4) shows that males were first affected by LEH at the age of 1.1-1.5 while female were a little late and have only been identified at the age of 1.6-2.0. In proportion the number of defects in female is higher than in the male with a quite significant comparison. LEH in male only increased in the age period 1.6 -2.0 and age 3.6-4.0 while female continued to experience an increase since the initial LEH was identified to reach the highest peak at age 4.6-5.0 and then the proportion declined. Age 5.6-6.0 was the last age class that can be identified in men while in female at the age of 6.6-7.0.

### 4.1.2. Selvicciola (SLV)

The population of the POV site is quite large and is divided in all age classes. Based on identification and data (table 4.4) it is illustrated that the number of LEH is 37.5% of the total population and less than the individuals who are not identified LEH as many as 75 individuals from 120 total populations. LEH is found in all age classes except infant (0-3 years old). LEH findings are mostly identified at the age of 35-50 years old for 13 individuals, this is in line with the largest age class in the population. then successively from young adult to child with the number of individuals respectively 10, 8 and 6 individuals. The rest is old adult with age 50+ and undetermined 4 individuals.

| Information | | | Age Classes | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Σ | | Infant (0–3 years) | | Child (3–12 years) | | Adolescent (12–20 years) | | Young Adult (20–35 years) | | Middle Adult (35–50 years) | | Old Adult (50+ years) | | Un-Detr | |
| N | n | % | n | % | N | % | n | % | n | % | n | % | n | % | N | % |
| Population | 120 | 100 | 13 | 10.8 | 18 | 15 | 14 | 11.6 | 14 | 11.6 | 23 | 19.1 | 8 | 6.6 | 30 | 25 |
| Sample LEH | 45 | 37.5 | 0 | 0 | 6 | 13.3 | 8 | 17.7 | 10 | 22.2 | 13 | 28.8 | 4 | 8.8 | 4 | 8.8 |
| Without LEH | 75 | 62.5 | 13 | 17.3 | 12 | 16 | 6 | 8 | 4 | 5.3 | 10 | 13.3 | 4 | 5.3 | 26 | 34.6 |

Table 4.4. Population number of linear enamel hypoplasia (LEH) based on age from Selvicciola site.

There is about 62% comparison between individuals identified by LEH and individuals who did not find LEH (table 4.5) of the total population. This comes from the majority of individuals recorded without teeth, 26 individuals or about 21%. The LEH findings were mostly identified by the dominance of 38 permanent teeth individually. The deciduous and permanent are 5 individuals and the rest are deciduous & include and deciduous each 1 individually. Population number based on sex (table 4.6) shows that it is dominated by 24% male, 11.6% female while 64% undetermined. But in this study focused on adult age to facilitate intra-population comparison with POV. Therefore, the total population taken 29 males, 14 females and 32 undetermined (see table 4.4) although LEH ranging from infants to sub-adults is still described.

| Information | | | Teeth | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Σ | | Permanent | | Deciduous | | Deciduous & Include | | Deciduous & Permanent | | Without teeth | |
| N | n | % | N | % | n | % | n | % | n | % | n | % |
| Population | 120 | 100 | 65 | 54.1 | 4 | 3.33 | 8 | 6.66 | 17 | 14.1 | 26 | 21.6 |
| Sample LEH | 45 | 37.5 | 38 | 84.4 | 1 | 2.2 | 1 | 2.2 | 5 | 11.1 | 0 | 0 |
| Without LEH | 75 | 62.5 | 27 | 36 | 3 | 4 | 7 | 9.3 | 12 | 16 | 26 | 34.6 |

Table 4.5. Population number of linear enamel hypoplasia (LEH) based on type of teeh from Selvicciola site.

| Information | | | Sex | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Σ | | Male | | Female | | Undetr | |
| N | n | % | N | % | n | % | n | % |
| Population | 120 | 100 | 29 | 24.1 | 14 | 11.6 | 77 | 64.1 |
| Sample LEH | 45 | 37.5 | 19 | 42.2 | 8 | 17.7 | 18 | 40 |
| Without LEH | 75 | 62.5 | 10 | 13.3 | 6 | 8 | 59 | 78.6 |

Table 4.6. Population number of linear enamel hypoplasia (LEH) based on sex, SLV.

Photo (left to right - top-bottom). Linear enamel hypoplasia from SLV sample: 4.3). Maxilla (sample 96: 90/8); 4.4). Mandibular (sample 52: 86/10); 9).; 4.5). Maxilla (sample 92: 90/4); 4.6). Mandibular (sample 58: 86/15)

Samples originating from the SLV population were identified not only in adult individuals but also in children aged 0.0-17 years old. From the data on the chart below (chart 4.5), it can be seen that LEH only occurs in 4 age classes, first appearing at age 1.1-1.5 and reaching the highest peak at age 2.6-3.0 and ending at age 3.6-4.0. LEH also appears at the second retention age (1.6-2.0 years) with the proportion of 2 NoD equal to 2 other age classes.

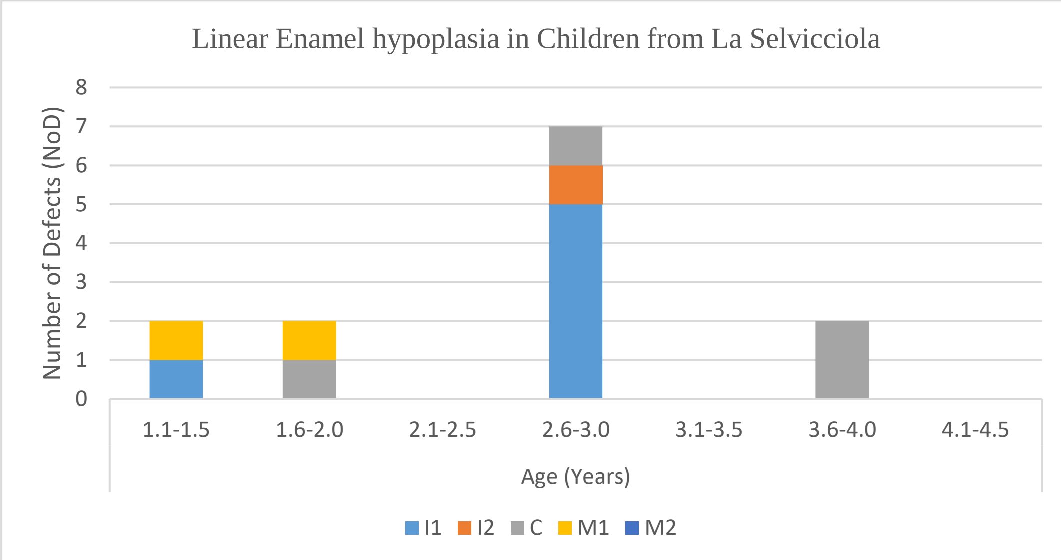


Chart 4.5. LEH age at death distribution in children from SLV

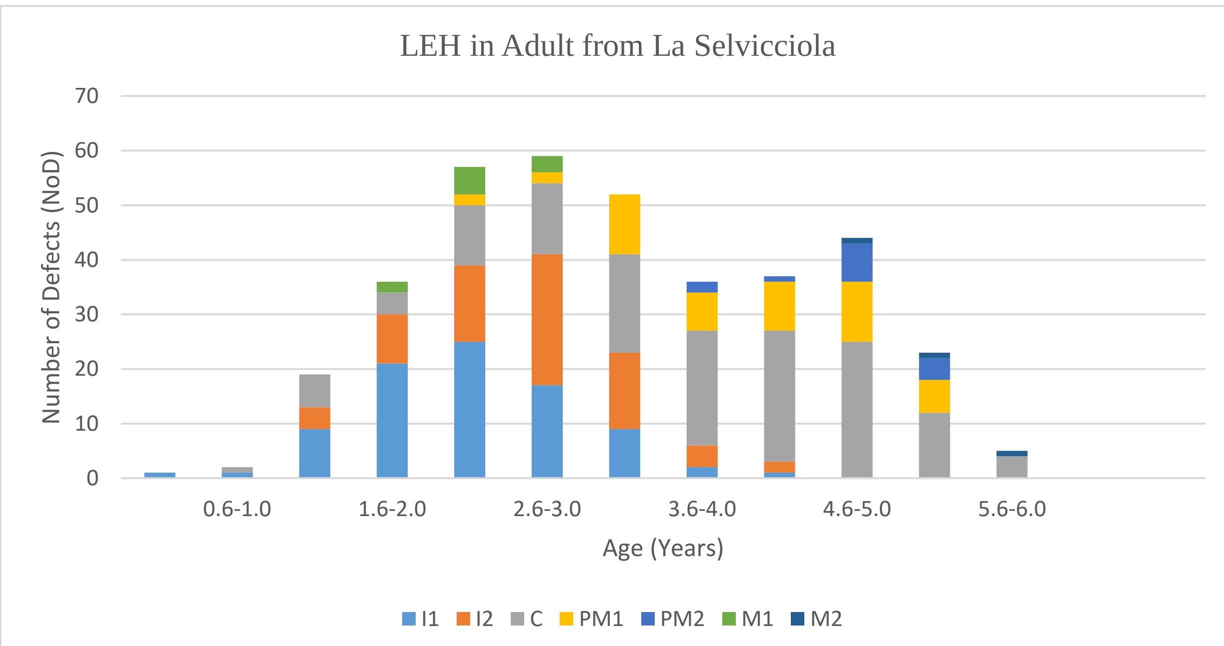


Chart 4.6. LEH age at death distribution in adult from SLV

The age at death of the distribution of LEH in adults from SLV samples (chart 4.6) illustrates that LEH is found at an earlier age of 0.0-0.5 years also at the age of 0.6-1.0 then ends at age 5.6-6.0. The effect of LEH is quite high in the next age after 2 years at the beginning with an average of above 20 NoD. The chart above shows the fluctuating LEH distribution by starting to increase at the age of 1.1-1.5 to reach the highest peak at ages 2.1-2.5 and 2.6-3.0 years.

Furthermore, decreased in the next age class before stagnating at the age of 3.6-4.0 and 4.1-4.6. At the age of 4.6-5.0 again increased and then decreased at the age of 5.1-5.6 and finally at the age of 5.6-6.0 as the last part of the distribution of the LEH in the SLV sample.

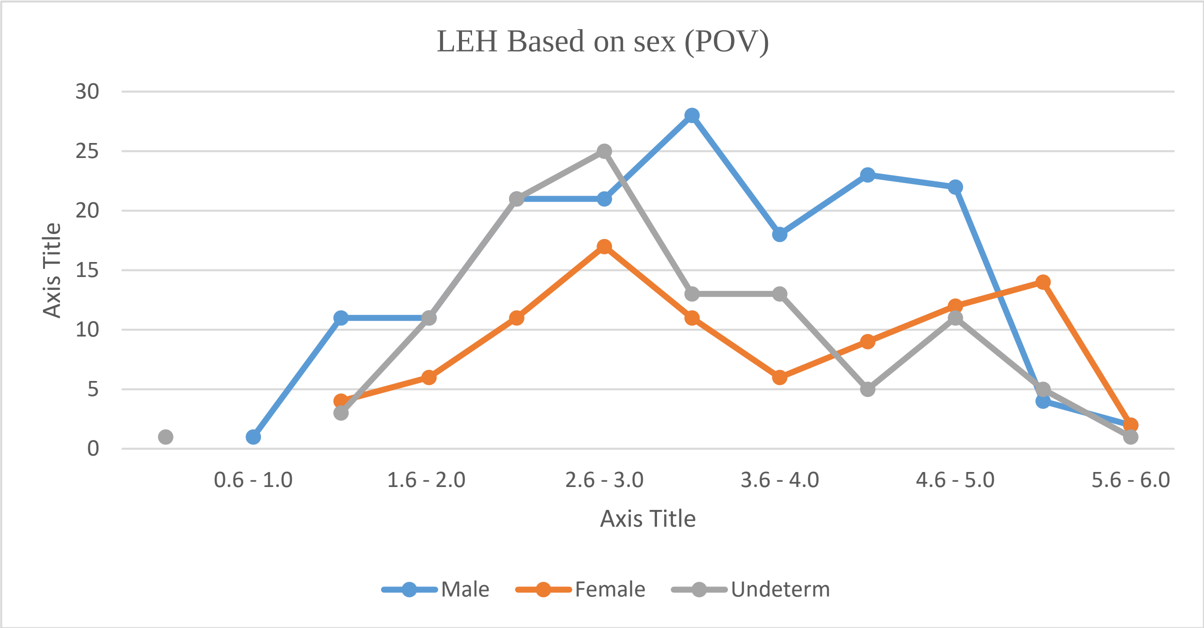


Chart 4.7. LEH age at death distribution based on sex

The data above (chart 4.7) shows that the LEH age at death distribution in males is higher than in females. This is in line with the presence of more than two times the number of male sex samples of females as well as more undetermined samples than female samples (tables 4 and 5). In terms of the age of initial defects, males begin at the age of 0.6-10 years while females at the age of 1.1-1.5 but the last are equally identified at 5.6-6.0. In addition, the age defects of 4.6-4.0 males fall dramatically in inverse proportion to females which continue to increase from age 4.1-4.5 and reach a peak at 5.1-5.6.

### 4.1.3. Comparison of LEH Defecst from Povegliano Veronese and Selvicciola Samples

Although the total number of individuals from the two populations is very much different from more than 2 times the POV 56 individuals and the SLV 120 individuals, the percentage of each sample is not much different between the two, 41% (*n = 23*) POV and 37.5% (*n*= 45) SLV.

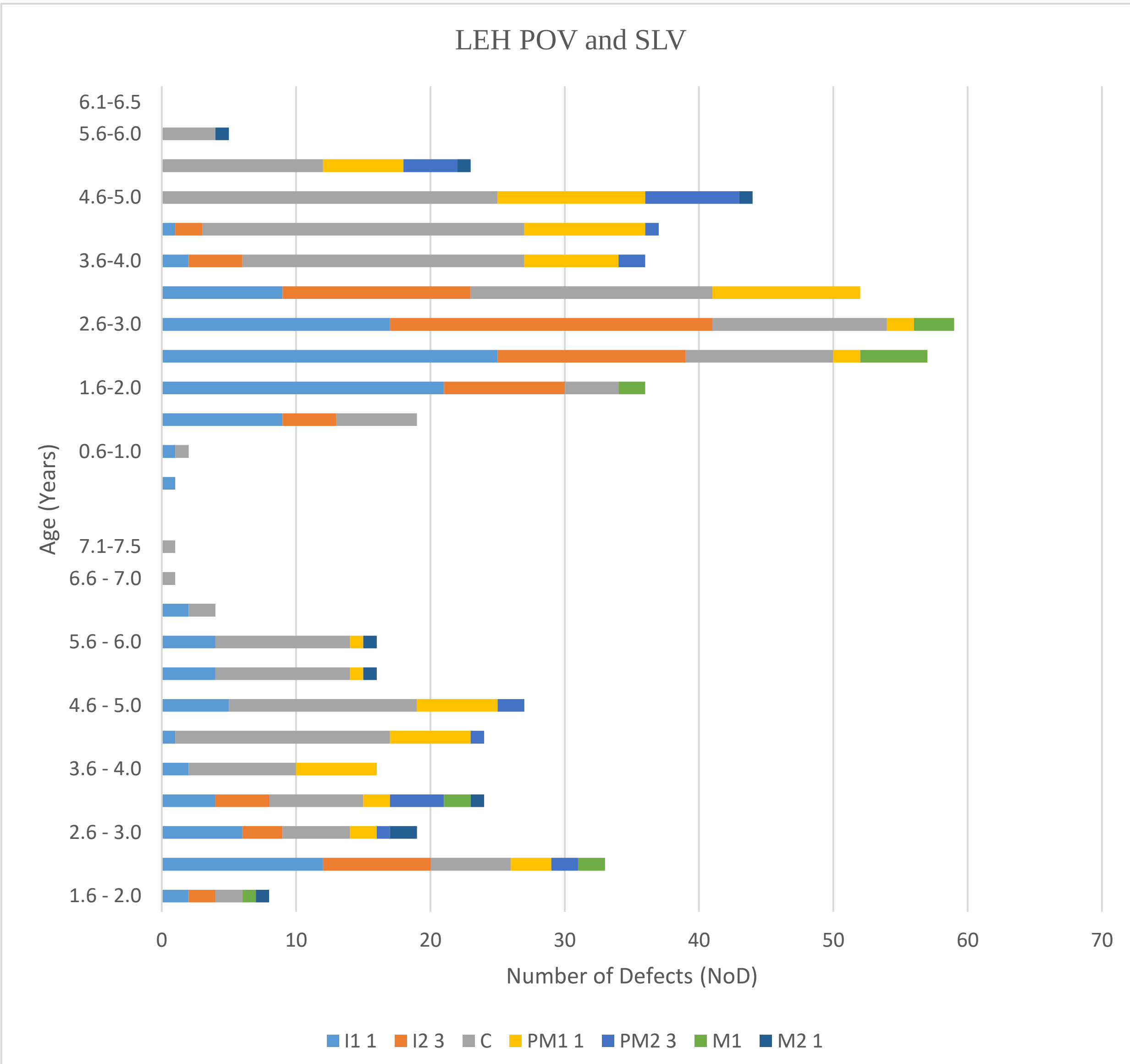


Chart 4.8. Comparison of LEH age at death distribution of POV and SLV

LEH distribution of age at death is quite significant difference between POV and SLV (chart 4.8). LEH hypoplastic defects in POV appear at ages 1.6 - 2.0 with a fairly high proportion while SLV appears earlier at age 0.0 - 0.5 years old with a low number of defects. Instead, LEH in the last POV is identified at age 7.1 - 7.5 years and SLV only found only until the age of 5.6 – 6.0 years. In terms of the LEH proposition, the POV number of defects reach their peak at ages 2.1 - 2.5 and 4.6 - 5.0 and tend to be stable at 15 NoD points between ages 5.1 - 5.5 and 5.6 - 6.0. The peak of SLV defects is at three ages ranging from 2.1-2.5, 2.6-3.0 and 3.1 -3.5 and decreases again in the 2 subsequent age periods before rising again at age 4.6 - 5. Then decreases to the end point of defects at age 5.6 - 7.0.

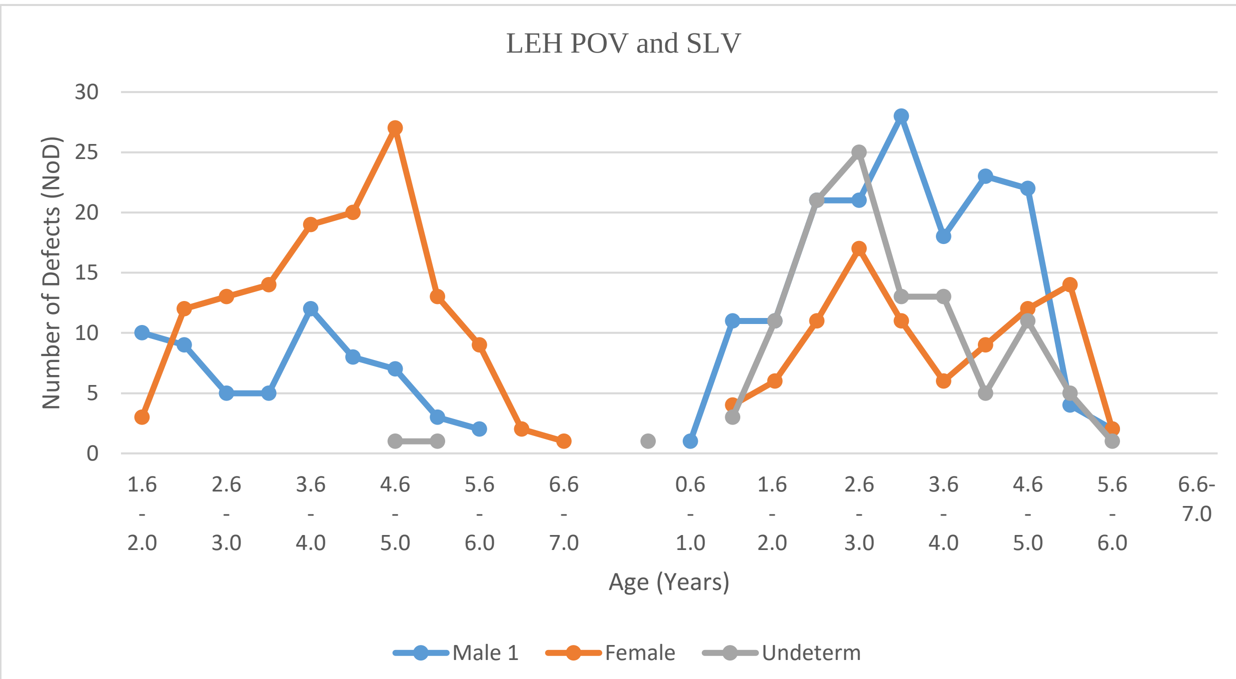


Chart 4.9. Comparison of LEH chronological distribution based on sex from POV and SLV

The difference in the level of defects in POV is very clearly seen by being dominated by females, but in SLV it is actually dominated by males, although in the last two age classes LEH in females rose sharply (chart 4.9). Furthermore, the initial defects, males and females in POV occur concurrently at the age of 1.6 - 2.0 years although not ended at the same age as the earlier males at the age of 5.6 - 6.0 and female 6.6 - 7.0. While SLVs differ in one age class at first, males at the age of 0.6-1.0 and female 1.1-1.5, but both are finally identified at the same age defects, 5.6 - 6.0. The proportion of undetermined samples in SLV is very high compared to POV in only two periods of age 4.6-5.0 and 5.1-5.5 years.

**4.2. Discussion**

Based on the analysis of the two samples from POV and SLV it is clear that overall the presence of LEH is mostly found in incisors and canines. Patterns of distribution of defects with specific categories of teeth identified have generally been frequently found in studies (Lanphear, 1990) with a focus on studies of incisors and canines (Wood, 1996; Oyamada 2012). Some researchers even used specific teeth that were considered to represent the LEH study with consideration of the number of defects that were found in these teeth. Not only that, Krenz-Niedbała, and Kozłowsk (2013), gave specifics in addition to the type of teeth as well as their presence between the molar or mandibular parts, they stated that the teeth most affected by defects were mandibular canines, followed by incisors and maxillaries while most teeth were not affected is proven to be premolar teeth. Because it is evidently that both types of teeth can provide information clearly related to the early age of the formation of enamel hypoplasia in an individual. However, the presence of premolar teeth should not be ruled out to obtain information related to linear enamel hypoplasia, especially if it is related to the distribution of age formed LEH.

In this study, premolars were also used as important samples from both POV and SLV as recommended by Goodman and Rose (1990), and Buikstra & Ubelaker (1994) as well as M1 and M2 molar teeth. Although some researchers excluded posterior teeth in the analysis (Miszkiewicz, 2015) with the consideration that posterior teeth showed age-related occlusal friction in adult samples (Miles, 1962; Hillson, 1996). From the research conducted provide information that premolar teeth have an important role in describing the last age affected by defects also in molar teeth although the defects are not as vulnerable as incisors and canines. Research results from the POV and SLV sites provide clear data that PM1 and PM2 premolar teeth have the older age affected by LEH with the usual age range of ages 5.1 - 5.6.

Furthermore, in general the experts agreed that the presence of M3 in studies related to LEH was not included in the data because the third molar is considered the only type of tooth that maintains evidence of the latest growth stage, it would be very difficult to find suitable defects. From this reason, only the developmental phases that can be observed simultaneously forming enamel regions in other teeth in the same individual teeth were included in this study (Hassett, 2014). Even Goodman did not include M3 as part of the calculation formula for Regression Equations for estimation of age (Goodman and Rose, 1990). However, with its presence identified it can provide information that shows evidence of the latest stage of growth in a population.

In the process of tooth growth, it has long been known that teeth grow nonlinearly and have inter- and intra-population variations in developmental time and crown height (Goodman and Rose, 1990; Hillson and Bond, 1997; Reid and Dean, 2006). However, the chronological distribution of hypoplastic defects in teeth will provide an explanation regarding the specific period when the individual (child) experiences an enamel growth disorder caused by adverse environmental factors and will allow researchers to infer the causes such as diet and infection (Collí et al., 2009; Krenz-Niedbała and Kozłowski, 2013). In addition, a number of studies and interpolation of social and cultural and economic factors are predicted to have an important role in hypoplasitic defects in individuals (Palubeckait et al., 2002; Miszkiewicz, 2015).

From the analysis conducted, in chart 4.8 it’s clear that LEH can be seen with a fairly high prevalence of stress indicators on dental crowns; 41% in POV and 37.5% in SLV. But, the numbers of lines on each tooth, so the number of stress events in the life course of an individual, is more frequent recurring in SLV. LEH in SLV starts at the age of 0.0 - 0.5 years with a difference of 2 age classes faster than the initial LEH from POV that starts at age 1.6-2.0 years. Meanwhile, if seen at the end of the defects, the opposite is true, LEH samples from SLV end at the age of 5.6-6.0 years while POV ends more slowly with a difference of 3 age classes, namely at the age of 7.1-7.5 years. Furthermore, SLV defects are also found in a sample of children with initial defects marked at the beginning of the age of 1.1-1.5 years and ending at the age of 3.6 -4.0 years with many peak defects found at the age of 2.6-3.0 years. Finally, although the LEH level in SLV is higher than the POV, the peak of the highest defects has almost the same pattern (see chart 12). Both samples from both POV and SLV started the highest peak of LEH in the age range between 2.1 - 2.5 to 3.1-3.5 years ago, equally decreasing at the age of 3.6-4.0 years and rising again in the age range 4.1-4.5 to age 4.6 - 5.0 before they both fell until the end of the age identified LEH.

With the presence of linear enamel hypoplasia in a sample from a population expert agree that this is an indicator of nutritional stress and pathology as a permanent marker of physiological stress during infancy (Goodman et al., 1980, Goodman et al., 1984; Goodman and Rose, 1991; Hillson, 1996; Miszkiewicz, 2015). The level of damage to enamel in the form of linear defects in enamel has been found in sectors of the population that are malnourished (Goodman et al., 1987, Goodman et al., 1991). Furthermore, LEH has been linked to conditions that might interfere with homeostasis of individuals with nutritional deficiencies that have been considered to be the main cause of disorders in enamel (Collí et al., 2009). The researchers clearly interpret that malnutrition is the main cause of the emergence of linear enamel hypoplasia (Sarnat and Schour, 1941; Goodman et al., 1991; Matee et al., 1992; Li et al., 1996: Liebe-harkort, 2012; Steckel and Rose, 2002; Miszkiewcz 2015; McKenna and Smith, 2017; Ungar et al, 2017; Rivera and Mirazón, 2017; Skinner and Skinner, 2017; El-Bayoumy et al., 2019; Limbo, 2019). Salivary gland hypofunction and changes in the composition of saliva may be a mechanism in which malnutrition is associated with dental caries, while altered eruption times can create challenges in the analysis of age-specific caries levels (Sheetal et al., 2013).

The difference in frequency and severity and age of the LEH when formed provides information on differences in stress levels in a population so that it can be used to evaluate health status and levels between populations (Goodman et al., 1980; Lanphear, 1990; Wright, 1997). In both populations studied in this research, the available data shows LEH level as a sign of separation in groups, where one has better lifestyle and richer support of diet. Although both samples from POV and SLV show a high LEH, the number of stress events during the life of individuals in SELV are much more frequent than in POV, peaking at ages 2.6-3.0 and 2.1-2.5. The LEH level of SLV is quite high which incidentally originated from the post-classical or medieval times has similarities with the results of research that has been conducted by researchers. Excerpted from Palubeckaitė et al. (2002), some researchers explain that a high prevalence of LEH is not uncommon in medieval populations (Goodman et al., 1980; Van Gerven et al., 1990; Malville, 1997).

Even so, there are some things to consider, for example the level of immunity of each individual in a population is different. In addition, looking at the sample characteristics of SLV which has worn teeth on the oclusal surface, whitewashing and peeling on the enamel and some teeth that are damaged even if they do not have teeth allows there are several factors that can influence the level of enamel hypoplasia including weaning (Goodman and Rose, 1990; Ogilvie et al., 1989; Skinner and Boesch, 2012), seasonal (Skinner and Pruetz, 2012), and parasitism (Suckling et al., 1986; Reid and Dean, 2000; Ritzman et al., 2008; Caufield et al., 2012). However, with the high frequency between individuals, it is possible to conclude that gission deficiency is the cause of high LEH on SLV. In addition, other evidence shows that the SLV population is identified as a population that is "poor" both in terms of social status and the type of subsistence economy. (Manzi et al., 1999).

Data on comparisons of LEH based on sex show significant differences between POV and SLV. Population samples from SLV have a higher frequency of male than female sex while from POV samples are just the opposite. However, in the case of SLV it cannot be compared between LEH levels in men and women because the number of samples between the two is very much different about 2 times where male sex is dominated. Even so, from charts 4.7 and 4.9, it appears that between male and female have a pattern of increasing and decreasing LEH with almost the same pattern. In addition, from the SLV sample there are several samples which cannot be identified based on their sex.

LEH levels in SLV are very clearly seen between males and females (charts 8 and 13). The female exceeds the LEH level of the male which is quite far away with the highest peak level around 27 number of defects in female and 13 in the male. Not only that, the proportion of early age LEH in female is also higher than in male, although at the age of early identified at the same age at the age of 1.6-2.0, males are higher than later at age 2.1-2.5 dominated by females. Furthermore, almost all age susceptible LEH levels are dominated by females until the late age of the affected LEH, female 6.6-7.0 while male 5.6-6.0.

The significant difference between LEH based on gender certainly raises questions about the cause of those. From some of the research conducted by these differences may be influenced by cultural influences and the existence of gender in a society. From the analysis of population from post medieval London also showed LEH levels in females having a greater amount of linear enamel hypoplasia, shorter intervals between defects, and a greater percentage of time of enamel formation affected by growth disturbance than male as a result of differences between men and women, or perhaps reflecting the same level of exposure which results in higher mortality and higher frequency of LEH among women who survive (King et al., 2005). In addition, LEH is also more common in women and is associated with an increase in sick days and a decrease in the speed of growth (Goodman et al., 1991).

The results of research from Oyamada (2012), the prevalence of linear enamel hypoplasia (LEH) in the teeth of Japanese samurai skeletal remains of the 17-18 century edo period showed a significant gender difference found in the prevalence of LEH with higher LEH levels in female samples compared to males from all types of teeth. This is consistent with the assumption that cultural values that favored men during this period resulted in preferential treatment of boys compared to girls where boys were raised more carefully than girls, and that girls were targeted by various types deprivation in early childhood.

In contrast to LEH research from the middle ages which represented the earliest Christian period (Griffin and Donlon, 2009), showing female shows a lower frequency of hypoplasia and delayed onset. In addition, childhood pressure is reduced in the Christian period and during infancy and female early childhood are tougher than their male counterparts. In a different case in Scandinavian periphery since the Viking times (Buckwalter and Baten, 2019), LEH's research shows equality between males and females. This shows that high gender equality currently has priorities during the Middle Ages even though it was understood that Scandinavian countries currently have very high values of women's autonomy.

Based on the explanation above, the relatively high frequency of LEH from individuals who are female than male raises many hypotheses related to the position of men and women in a population. The results of LEH reflect the lack of nutrition in women compared to men as a result of high LEH in women. Therefore, both the comparison of LEH intrapopulation levels between POV and SLV and interpopulation related to sex in the POV population requires further research to provide a comprehensive interpretation as a complement in eliciting explanations related to LEH in both populations.

# CHAPTER FIVE

# 5. Conclusion and Future Research

## 5.1. Conclusion

From the results of the analysis and discussion above, it is evident a need for research and comprehensive data to get further results. In selecting dental categories, it is not only focused on incisors and canines, although it is known that both types of teeth are considered to have been represented in studies related to LEH. However, to get complete data and to strengthen the results of the study, other teeth need to be considered, especially premolars and molars as a complement to the distribution of the LEH defects in later phases of life.

Comparison of the intrapopulation of the two sites is clearly seen that the LEH of the SLV sample has a much more frequent stress events testified by the number of lines on each pathological tooth, than in the POV sample, suggesting a high level of malnutrition of the sample. In terms of LEH development patterns, the two populations have almost the same pattern, but have differences in the age at the beginning and end of the LEH impact. The initial POV sample was affected by the LEH defect at age 2.0-2.5 and ended at the age of 7.1-7.0. While the initial SLV is affected by LEH at a relatively very early age at the age of 0.0-0.5 ending at the age of 5.6 - 6.0. The age peaks of the LEH chronological distribution of the two populations are at almost the same age, differing only in one age class where POV at 2.1-2.5 and SLV at 2.6-3.0. In chart 4.8 the highest peak of LEH is in the age range between 2.1-2.5 to the age of 3.1-3.5. From the LEH comparison based on sex, POV is dominated by females while the sample from POV is quite the opposite.

Furthermore, interpopulation comparisons were taken from the LEH POV sample based on sex because the comparative data between male and female samples was relatively similar while the samples from the SLV site differed significantly between men and women and the number of samples undetermined in terms of sex. From the analysis it was found that female individuals had a higher frequency of LEH than male individuals. Women and men have the same age at the beginning of LEH at the age of 1.6-2.0 but female continues to increase until it reaches its peak at the age of 4.6 - 5.0 years old. Male individuals have the final age affected by LEH faster than female individuals. With the higher frequency of LEH in women than in men it is assumed that women are more malnourished than men. Other hypotheses are possible in terms of population culture where there is a possibility of different treatment between men and women and men in society.

Different patterns related to the chronological distribution of enamel hypoplasia this research has provided an illustration of the magnitude of malnutrition influences from both populations resulting in high frequency of LEH in the populations. Many factors can be considered as cause of LEH; systemic pathologies, infection, anemia, vitamin D deficiencies, parasites and other diseases, as well as environmental and socio-cultural factors.

### 5.2. Future Research

Future research into these two populations can be combined with a number of analytical techniques to complement the explanations that existed by LEH in the two populations. An analytical technique that allows X-ray micro tomography ((μCT) to make cross sections of physical objects that can be used to recreate virtual models (3D models) without damaging the original object (Marchewka et al., 2014; Ribeiro et al., 2015; Agirre, 2019). Which is possible to see the thickness of the email as due to ameloblast activity for assessment of enamel hypoplasia as an indicator of nutritional status. Also, SEM-EDS (Scanning Electron Microscopy/Energy Dispersive X-Ray Spectroscopy) (Sabel et al., 2010; Kammoun et al., 2019) to see the morphology and structure of materials with high magnification and resolution that can provide qualitative and quantitative results.

In addition, using XRD (Zheng et al., 1997; Mahoney et al., 2004; Lu et al., 2019) can provide crystalline chemical composition to the teeth to see the difference between teeth that are clogged with LEH and healthy teeth. Finally, future research is very important to conduct research related to paleo diet with Carbon ($^{13}C/^{12}C$) and Nitrogen ($^{15}N/^{14}N$) isotope and mobility by using Oxygen ($^{18}O/^{16}O$), Strontium ($^{87}Sr/^{86}Sr$) or Sulfur ($^{34}S/^{32}S$) from both individuals of the two sites to get a picture of the relationship between diet and LEH associated with nutrients consumed also related to individuals originating from the region and environment. With this research it is hoped to be able to add and complete research between the two populations of the Povegliano Veronese and La Selvicciola populations.

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# APPENDIX

**APPENDIX**

**A. List Burial of Povegliano Veronese (VOP)**

| No. | Site | Acronym (Nº) | Sex | Age | Teeth |
|---|---|---|---|---|---|
| 1 | P.V. | 29D | M | 51-65 | Perm. |
| 2 | P.V. | 40B | F | 18-22 | NO |
| 3 | P.V. | 41 | Undetermined | Undetermined | NO |
| 4 | P.V. | 45B | M | 33-35 | Perm. |
| 5 | P.V. | 96B | M | 29-33 | Perm. |
| 6 | P.V. | 100 | F | 17-21 | Perm. |
| 7 | P.V. | 102B | M | 35-39 | Perm. |
| 8 | P.V. | 213 A/2 | Undetermined | Undetermined | Perm. |
| 9 | P.V. | 213B | M | 43-47 | Perm. |
| 10 | P.V. | 215 | M | 40-45 | Perm. |
| 11 | P.V. | 215B | F | 20-24 | Perm. |
| 12 | P.V. | 215 C | F | 40-45 | Perm. |
| 13 | P.V. | T 220B | M | 40-49 | NO |
| 14 | P.V. | 349 | F | 34-38 | Perm. |
| 15 | P.V. | 352B | F | 34-38 | Perm. |
| 16 | P.V. | 359A | F | 22-26 | Perm. |
| 17 | P.V. | 359B | Undetermined | Undetermined | NO |
| 18 | P.V. | 362B | M | 37-41 | Perm. |
| 19 | P.V. | 364B | M | 44-48 | Perm. |
| 20 | P.V. | 365B | F | 45-49 | Perm. |
| 21 | P.V. | 366 | M | 31-35 | Perm. |
| 22 | P.V. | T 369 | M | 43-47 | Perm. |
| 23 | P.V. | 378B | M | 46-50 | Perm. |
| 24 | P.V. | 380B | M | 44-48 | Perm. |
| 25 | P.V. | 382 | F | 44-46 | Perm. |
| 26 | P.V. | 384 | M | 46-50 | Perm. |
| 27 | P.V. | 388B | M | Undetermined | NO |
| 28 | P.V. | 387/1 | M | 35 | Perm. |

| | | | | | |
|---|---|---|---|---|---|
| 29 | P.V. | 389B | F? | Undetermined | NO |
| 30 | P.V. | T 391 A | F | 23-27 | Perm. |
| 31 | P.V. | 394 | M | 30-34 | Perm. |
| 32 | P.V. | 399B | Undetermined | Undetermined | NO |
| 33 | P.V. | 402A | Undetermined | Undetermined | Perm. |
| 34 | P.V. | T402B | Undetermined | Undetermined | NO |
| 35 | P.V. | 404B | M | 24-30 | Perm. |
| 36 | P.V. | T 408A | Undetermined | Undetermined | NO |
| 37 | P.V. | 413B | F | 35-39 | Perm. |
| 38 | P.V. | 414B | M | 45-55 | perm. |
| 39 | P.V. | T 415B | F | 60 | No |
| 40 | P.V. | 416B | Undetermined | Undetermined | NO |
| 41 | P.V. | T 417 | M | 34-38 | Perm. |
| 42 | P.V. | 423/A/1 | Undetermined | Undetermined | NO |
| 43 | P.V. | 426B | F | 44-48 | Perm. |
| 44 | P.V. | T 425B | F | 40-44 | Perm. |
| 45 | P.V. | 428B | F | 32-37 | Perm. |
| 46 | P.V. | T 429B | F | 46-50 | Perm. |
| 47 | P.V. | T 430B | F | 36-40 | Perm. |
| 48 | P.V. | T 423B | M | 32-36 | Perm. |
| 49 | P.V. | 450B | M | 16-20 | Perm. |
| 50 | P.V. | T454B | Undetermined | Undetermined | ? |
| 51 | P.V. | T456B | F | 39-43 | Perm. |
| 52 | P.V. | 458 | F | 46-50 | Perm. |
| 53 | P.V. | 484 A/2 | Undetermined | 24-30 | Perm. |
| 54 | P.V. | 487B | F | 43-47 | Perm. |
| 55 | P.V. | 488B | F | 48-50 | NO |
| 56 | P.V. | 489 A/2 C/1 | M | 33-37 | Perm. |

### B. List Burial of Selvicciola (SLV)

| No. | Site | Acronym (Nº) | Sex | Age | Teeth |
|---|---|---|---|---|---|
| 1 | SLV | 82/S.C.x | Undetermined | Undetermined | No |
| 2 | SLV | 82/S.C.y | Male | 40-50 YO | Perm. |
| 3 | SLV | 82/3 | Male | Undetermined | No |
| 4 | SLV | 82/3bs | Undetermined | 40-50 YO | Perm. |
| 5 | SLV | 84/1 | Undetermined | 2-3 YO (SUB) | Deciduous and included |
| 6 | SLV | 84/2x | Undetermined | 1-3 YO (SUB) | No |
| 7 | SLV | 84/2y | Undetermined | Undetermined | Perm. |
| 8 | SLV | 84/3 | Male | 50+ YO | Perm. |
| 9 | SLV | 84/4 | Male | 30-40 YO | Perm. |
| 10 | SLV | 84/5x | Female | Undetermined | Perm. |
| 11 | SLV | 84/5y | Undetermined | 19-20 YO | Perm. |
| 12 | SLV | 85/1x | Undetermined | 17 YO | Perm. |
| 13 | SLV | 85/1y | Undetermined | Undetermined | No |
| 14 | SLV | 85/2x | Male | 40-50 YO | Perm. |
| 15 | SLV | 85/2y | Undetermined | 14-15YO (SUB) | Perm. |
| 16 | SLV | 85/3 | Female | 30-40 YO | Perm. |
| 17 | SLV | 85/4A | Undetermined | 10-15YO (SUB) | Deciduous and perm. |
| 18 | SLV | 85/4B | Female | 50+ YO | Perm. |
| 19 | SLV | 85/5 | Male | Undetermined | Perm. |
| 20 | SLV | 85/6 | Male | 25-30 YO | Perm. |
| 21 | SLV | 85/7A | Male | 40-45 YO | Perm. |
| 22 | SLV | 85/7B | Undetermined | 3-6 YO (SUB) | Deciduous and perm. |
| 23 | SLV | 85/8x | Undetermined | 3-5 YO (SUB) | Deciduous and included |
| 24 | SLV | 85/8y | Undetermined | 15-17YO (SUB) | No |
| 25 | SLV | 85/8z | Undetermined | 1-3 YO (SUB) | No |
| 26 | SLV | 85/9 | Undetermined | 18-20 YO | Perm. |
| 27 | SLV | 85/10 | Male | 50+ YO | Perm. |
| 28 | SLV | 85/12 | Undetermined | 7-8 YO (SUB) | Deciduous and perm. |
| 29 | SLV | 85/12 sopra x | Undetermined | 7-8 YO (SUB) | Deciduous and perm. |
| 30 | SLV | 85/12 sopra y | Undetermined | 15-17YO (SUB) | Perm. |
| 31 | SLV | 85/13A | Undetermined | 4-5 YO (SUB) | Deciduous and included |
| 32 | SLV | 85/13B | Undetermined | 8-10 YO (SUB) | Deciduous and included |
| 33 | SLV | 85/15 | Female | 30-40 YO | Perm. |
| 34 | SLV | 85/16 | Male | 40-45 YO | Perm. |

| | | | | | |
|---|---|---|---|---|---|
| 35 | SLV | 85/17 | Male | 35-40 YO | Perm. |
| 36 | SLV | 85/17 sopra cop. | Undetermined | 1-3 YO SUB | Deciduous and perm. |
| 37 | SLV | 85/18A | Female | 30-40 YO | Perm. |
| 38 | SLV | 85/18B | | 1 -3 YO (SUB) | Deciduous and perm. |
| 39 | SLV | 85/18 sopra cop. | Undetermined | Undetermined | No |
| 40 | SLV | 85/19 | Undetermined | 45-50 YO | Perm. |
| 41 | SLV | 86/1 | Male | 30-35 YO | Perm. |
| 42 | SLV | 86/2 | Male | 30-35 YO | Perm. |
| 43 | SLV | 86/3 | Female | 35-45 YO | Perm. |
| 44 | SLV | 86/4A | Undetermined | Undetermined | Perm. |
| 45 | SLV | 86/4B | Female | 35-45 YO | Perm. |
| 46 | SLV | 86/5 | Undetermined | 1-2 YO SUB | Deciduous |
| 47 | SLV | 86/6 | Undetermined | 50+ YO | No |
| 48 | SLV | 86/87 | Undetermined | Undetermined | No |
| 49 | SLV | 86/8x | Undetermined | 20-25 YO | Perm. |
| 50 | SLV | 86/8y | Undetermined | 3-5YO (SUB) | Deciduous and perm. |
| 51 | SLV | 86/9 | Male | 20-30 YO | Perm. |
| 52 | SLV | 86/10 | Female | 17-18 YO | Perm. |
| 53 | SLV | 86/11A | Undetermined | Undetermined | No |
| 54 | SLV | 86/11B | Undetermined | 10-15YO (SUB) | Perm. |
| 55 | SLV | 86/12 | Undetermined | Undetermined | Perm. |
| 56 | SLV | 86/13 | Undetermined | Undetermined | Perm. |
| 57 | SLV | 86/14 | Female | 20-25YO | Perm. |
| 58 | SLV | 86/15 | Undetermined | 14-15YO (SUB) | Perm. |
| 59 | SLV | 86/16 | Male | 35-45 YO | Perm. |
| 60 | SLV | 86/17 | Female | 50+ YO | Perm. |
| 61 | SLV | 86/18 | Male | 30-40 YO | Perm. |
| 62 | SLV | 86/19 | Undetermined | 5-10 YO (SUB) | Deciduous and perm. |
| 63 | SLV | 86/20 | Undetermined | 0-6 YO (SUB) | Deciduous |
| 65 | SLV | 87/1 | Undetermined | 35-45 YO | Perm. |
| 66 | SLV | 87/2 | Undetermined | 20-30 YO | Perm. |
| 67 | SLV | 87/4A | Male | 30-40 YO | Perm. |
| 68 | SLV | 87/4B | Undetermined | Undetermined | No |
| 69 | SLV | 87/5 | Undetermined | 30-35 | Perm. |
| 70 | SLV | 87/6 | Undetermined | 2-3 YO (SUB) | Deciduous and perm. |
| 71 | SLV | 87/8 | Undetermined | 5-10 YO (SUB) | No |
| 72 | SLV | 87/9 | Male | 30-40 YO | Perm. |

| | | | | | |
|---|---|---|---|---|---|
| 73 | SLV | 88/2x | Undetermined | 15-20YO (SUB) | Perm. |
| 74 | SLV | 88/2y | Undetermined | 20-30 YO | No |
| 75 | SLV | 88/2z | Undetermined | Undetermined | Perm. |
| 76 | SLV | 88/2w | Undetermined | 3-4 YO | Deciduous and perm. |
| 77 | SLV | 88/3 | Male | 20-25 YO | Perm. |
| 78 | SLV | 88/4x | Male | 20-30 YO | Perm. |
| 79 | SLV | 88/4y | Undetermined | Undetermined | No |
| 80 | SLV | 88/5x | Male | 30-40 | Perm. |
| 81 | SLV | 88/5y | Female | Undetermined | No |
| 82 | SLV | 89/2 | Undetermined | Undetermined | No |
| 83 | SLV | 89/3 | Undetermined | Undetermined | Perm. |
| 84 | SLV | 89/4 | Undetermined | 6-8 YO (SUB) | Deciduous and perm. |
| 85 | SLV | 89/5 | Male | 35-40 YO | Perm. |
| 86 | SLV | 89/6 | Undetermined | 3-4 YO (SUB) | Deciduous and included |
| 87 | SLV | 89/7 | Female | 50+ YO | Perm. |
| 88 | SLV | 89/8 | Male | 40-50 YO | Perm. |
| 89 | SLV | 90/1 | Undetermined | 6-12 YO (SUB) | Deciduous and perm. |
| 90 | SLV | 90/2 | Undetermined | 2-3 YO (SUB) | Deciduous and perm. |
| 91 | SLV | 90/3 | Undetermined | 2-4 YO (S)UB | Deciduous and included |
| 92 | SLV | 90/4 | Female | 20-30 YO | Perm. |
| 93 | SLV | 90/5 | Male | 50+ YO | Perm. |
| 94 | SLV | 90/6 | Male | 20-25 YO | Perm. |
| 95 | SLV | 90/7 | Female | 20-25 YO | Perm. |
| 96 | SLV | 90/8 | Undetermined | 8-10 YO SUB | Deciduous and perm. |
| 97 | SLV | 90/9 | Undetermined | 4-5 YO SUB | Deciduous and included |
| 98 | SLV | 90/10 | Undetermined | 2-3 YO SUB | Deciduous and perm. |
| 99 | SLV | 90/11 | Undetermined | 5-10 YO SUB | Deciduous and perm. |
| 100 | SLV | 90/13x (A) | Male | 50+ YO | Perm. |
| 101 | SLV | 90/13y (bis b) | Male | 30-40 YO | Perm. |
| 102 | SLV | 91/12 | Undetermined | Undetermined | No |
| 103 | SLV | 91/5 | Male | Undetermined | Perm. |
| 104 | SLV | 91/5b | Undetermined | 6-7 YO SUB | Deciduous and perm. |
| 105 | SLV | 91/7 | Undetermined | 40-45 | No |
| 106 | SLV | 91/8 | Undetermined | 14-15 YO UB | Perm. |
| 107 | SLV | 91/11 | Undetermined | 2-3 YO SUB | Deciduous and included |
| 108 | SLV | QN2 US1 | Undetermined | Undetermined | Perm. |
| 109 | SLV | QN6US1x | Undetermined | 2-3 YO SUB | Deciduous |
| 110 | SLV | QN6US1y | Undetermined | Undetermined | Perm. |
| 111 | SLV | QN7US0 | Undetermined | Undetermined | No |

| | | | | | |
|---|---|---|---|---|---|
| 112 | SLV | QN7US1 | Undetermined | Undetermined | No |
| 113 | SLV | QN8US2x | Undetermined | 2-3 YO SUB | Deciduous |
| 114 | SLV | QN8US2y | Undetermined | 6-7 YO SUB | No |
| 115 | SLV | QN8US2z | Undetermined | 14-15 YO SUB | No |
| 116 | SLV | QN8US2w | Undetermined | Undetermined | No |
| 117 | SLV | QP1US1 | Undetermined | Undetermined | No |
| 118 | SLV | QP2US1 | Undetermined | Undetermined | No |
| 119 | SLV | QP5US1 | Undetermined | Undetermined | Perm. |
| 120 | SLV | QP6US1 | Undetermined | Undetermined | No |
| 121 | SLV | 9M/10 T.3 | Undetermined | Undetermined | No |

ARCHMAT

ERASMUS MUNDUS MASTER

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ΑΡΙΣΤΟΤΕΛΕΙΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΘΕΣΣΑΛΟΝΙΚΗΣ

SAPIENZA UNIVERSITÀ DI ROMA

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