

Possible micronutrient deficiency disease in Medieval non-adults from a religious alpine context in northeastern Italy

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Abstract. Recent paleopathological investigations, aimed at identifying and proposing new morphological criteria to diagnose possible micronutrient deficiencies in the human skeletal sample, have opened new interpretative perspectives in bioarchaeological contexts, enriching them with their biocultural context. Particular importance is given to the analysis of pathologies related to non-adults, as they represent a human sample more susceptible to environmental insults, providing a valuable biological record to explore otherwise inaccessible aspects. The study focused on the non-adult osteological sample found in the church of San Vittore in Tonadico, Trento (Northeast Italy). Morphological osteological analyses were conducted to examine any present pathologies. The sample is characterized by the presence of diseases related to micronutrient deficiencies, which have been analyzed and interpreted from a biocultural perspective. This work fits into a research line that, in recent years, has explored the paleopathological aspects of Alpine populations in northern Italy, with particular attention to the medieval and modern periods, which are still relatively unexplored but of enormous scientific relevance.

Key words: bioarchaeology, rickets, scurvy, nonadults, Alps, Middle Ages, paleopathology, Italy

Introduction

The archaeological intervention at the Church of San Vittore in Tonadico (TN) strictly followed a stratigraphic excavation approach and aimed primarily at documenting the situation beneath the internal flooring. Not the entire surface was affected but only a portion, totaling approximately 29 square meters out of the total 80 square meters (Figure 1). The determination was guided by the indications of a geophysical survey and the more practical needs of clearing the portions that had to be removed to insert the drainage systems outlined in the redevelopment project.

What was not feasible at the time was the examination of the masonry above the excavation lines, which would have been useful for expanding the knowledge but was impractical due to the presence of completely

plastered walls. From this perspective, the observation was thus limited to the wall sections exposed by the excavations, essentially referring to the lower courses and foundations—entirely insufficient for a comprehensive assessment of the material and techniques employed by the builders. The archaeological investigation also led to the discovery of the graves subject to this study, directly referencing the contribution published by Dr. Enrico Cavada and the undersigned in a small and modest monographic publication dedicated to the historical, archival, cultural, and archaeological aspects of the context (Cavada, 2017).

The foundation of the church and its context

The archaeological method has ascertained that the church's structure belongs to a single construction

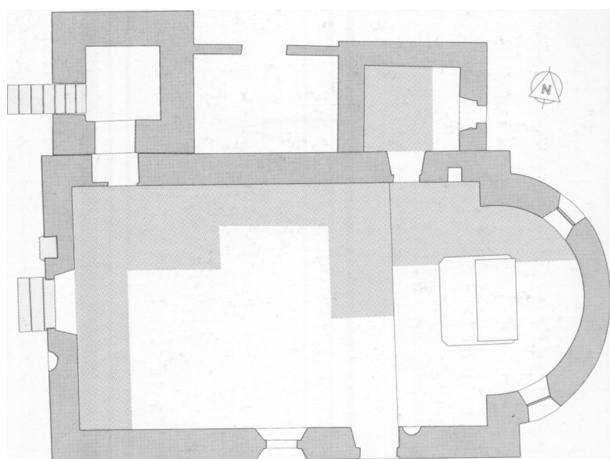


Figure 1. Schematic plan of the church of San Vittore in Tonadico (TN). The surfaces investigated by archaeological analysis are highlighted in light gray.

phase, coinciding with its foundation, and that the building remains intact, with few transformations primarily related to modifications of external additions (bell tower and sacred colonnade), flooring, ceilings, and roofing. The choice of the location, although isolated, was not random. The building stands in a point of great visibility, dominating from the end of a slope over the valley floor and facing the pieve church of Santa Maria, a pastoral center for all the inhabited centers in the valley, attested since 1206 (Cavada & Rapanà, 2013). Mentioned from 1053-1078 and a stronghold of the Feltrine Church, the castle is the seat of *ministeriali* (stewards and vice-domains entrusted with administrative functions and the collection of proceeds, duties, tolls, rents, and revenues owed to the bishop by the men of the entire Primiero and paid here). The constructed church is a rectangular plan of about 14.50m x 7.80m (external measurements), a single-nave structure of approximately 10.50m x 6.10m, oriented east-west with a projecting apse at the end, 2.70m deep from the spring line, distinct and semi-circular. The entire eastern and northern section of the building was directly set in the natural deposit: compact, light brown-yellowish soil with sands, silts, and internal landslide boulders, cut with excavation works on-site. Conversely, the longitudinal and western perimeter walls were built at different progressive elevations, higher at the eastern end and lower at the opposite end, demonstrating an original sloping

condition of the terrain. Hence, in the downhill parts, the foundations had a larger width with the use of larger but also more irregular stones. A horizontal recess marks the transition from the elevated masonry, with reduced thickness, to a level where the builders leveled the interior floor by bringing in soil from both the excavation of the substrate and the removal of a pedogenized cover soil. This situation is particularly observed in the western half of the nave and towards the facade with the recovery in the brought-back layer of fragments of ceramics, about ten in total, attributable to refractory mixture containers of still an early medieval tradition. As for the architecture, the corner walls observed in the excavation points consistently exhibited a bonded structure, evidence of the unity of the construction. The construction material is stone, mostly resulting from quarrying actions and direct clearing on-site or at a short distance from it. Essentially, these are limestone blocks from landslides, but also small to medium-sized pebbles of metamorphic rock. There are no reused stones documented, which, if present, would have indicated the existence of pre-existing constructions, on-site or nearby.

The preparation in the wall construction simply occurred by dimensionally adapting the rough-cut blocks, which, on the surface, are arranged with the breaking face positioned frontally or horizontally to the laying plane. Sections of the wall observed by Prisca Giovannini under pieces of torn plaster during the intervention on the mural fresco cycle highlighted, albeit partially, a wall in courses with leveling beds in mortar and wedges. Mortar composed of aerial lime, clays, and variously sized aggregates present in the wall section, where the employed clasts were generally small with flakes. A more accurate lithotechnical intervention was carried out on the jambs of the apse entrance and the lateral access space, becoming visible after the removal of the covering plaster. Here, well-squared blocks of carbonate stone (travertine) were used, cut with a flat point, and laid with straight, almost millimetrically thin joints. The finish - also observed during the restoration of the mural fresco cycle - affected all the facades, both internal and external, using a mortar plaster uniformly applied in a rough-cut style, followed by the application of a second, finer mortar layer that gave the surface a final rough appearance, then used to

anchor the pictorial support that completely covered the walls of the nave. The finishing seems to have occurred on a substrate with bedding mortar flowing from the joints, smoothed with a sliding technique, following good construction practice observed also in the nearby church of San Martino in Fiera, regarding the older construction phase (period I; first half of the 13th century) (Bellosi et al., 2013) and, more generally, on walls of Romanesque origin in both civil and religious contexts.

Unfortunately, no trace of the original altar or the floor from the ancient period has been preserved in the church. However, it can be hypothesized that the altar was in slabs or, more simply, made of wood—a material commonly used but seldom found unless in entirely exceptional cases. The current nave has two entrances, a central one in the facade wall and a lateral one in the southern perimeter. The evidence is faint, but the measurements of the windows appear to match those of the ancient openings, modified between the 15th and 16th centuries with the insertion of new pointed stone portals and the rectification of the arch and internal jambs, which appear splayed in the case of the main entrance.

Materials and methods

The excavation revealed six pits dug into the ground, five of which have been interpreted as tombs (Figure 2, tombs b-f). The osteoarchaeological sample consists of 4 nonadults. The skeletons' bone tissue is in an optimal state of preservation and conservation. The age at death was estimated from the length of the shaft of long bones (Maresh, 1970; Fazekas & Kosa, 1978), from the observation of the epiphyseal bone fusion (Schaefer et al., 2009), and from the evaluation of the development of the teeth (Ubelaker, 1979). In the case of conflicting results, the determination of dental age has been preferred, taking advantage of its low dependence on nutritional stress and disease (Elamin & Liversidge, 2013). Individuals have been classified following the age classes proposed by Buikstra and Ubelaker: stillbirths (<0 years), infants (0-3 years), and children (>4 years). Macroscopic observations were performed with the naked eye and with a magnifying glass. Bone anomalies, identified as possible pathologies, have been compared with the clinical and paleopathological literature (Ortner & Ericksen, 1997; Ortner & Mays, 1998;

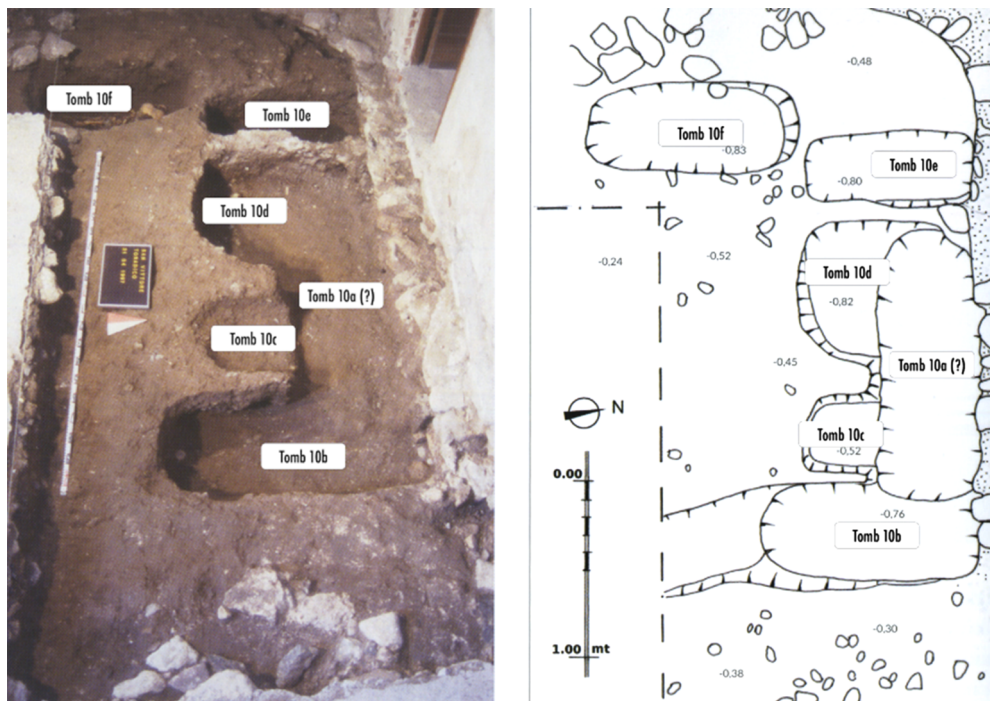


Figure 2. Tombs inside the church of San Vittore in Tonadico (TN). Position, morphology, and sequence. Planimetric survey and view at the end of the excavation.

Ortner, 2003; Brickley & Ives, 2006; Mays et al., 2006; Lewis, 2007; Mays, 2008; Geber & Murphy, 2012; Schattmann et al., 2016; Brickley et al., 2018; Buikstra, 2019; Brickley et al., 2020).

The features considered for the diagnosis include pathological changes like abnormal porosity and new bone formation both in cranial and post cranial bones, lytic phenomena, morphological variation (bowing of long bone, flaring), growth plate changes and fractures (Ortner & Ericksen, 1997; Ortner & Mays, 1998; Ortner et al., 1999; Ortner et al., 2001; Ortner, 2003; Brickley & Ives, 2006; Mays et al., 2006; Mays, 2008; Geber & Murphy, 2012; Schattmann et al., 2016; Brickley et al., 2018; Snoddy et al., 2018; Buikstra, 2019; Brickley et al., 2020). We recorded as probable, possible, non-diagnostic and under evaluation every feature linked to C or D deficiency according with to the paleopathological literature.

Results

Only the skeleton of one individual buried inside the medieval church of San Vittore has been preserved (Figure 3), while for three other individuals,



Figure 3. Photograph of tomb 10f containing the skeletal remains of a non-adult.

archaeological investigation has allowed the recovery of only a few elements, all out of context and, therefore, cannot be securely linked to a specific tomb (Figure 5, 5). These are the scattered bones of three children: the first died shortly before or immediately after birth (Figure 5, 5 on the left), the second at around 18 months of age (Figure 5, 5 in the middle), and the third around 5-6 years of age (Figure 5, 5 on the right). Additional data are available for the individual found in tomb 10f, which is sufficiently complete. Recovered in a primary position and in anatomical connection (Figure 4, 1), it is a child of about 16 months of age, with the exact gender not precisely determinable, buried in a supine position at the bottom of a pit, possibly wrapped in a cloth with the head to the north and the feet to the south, the arms and legs probably extended or slightly flexed.

The preservation status of the skeleton is decent and almost complete in its parts. The skull, mandible, trunk with intact ribs and spine, pelvis, and upper and lower limbs are present, except for the bones of the hands and feet, which are missing. The right scapula and clavicle are present, while only a fragment remains of the left clavicle, and the scapula is absent. The front right part of the skull shows a green discoloration (Figure 4, 2) due to contact with small sheets of copper or bronze, which, found in the tomb, have been interpreted as parts of an ornament, possibly a headdress.

Discussion

The excavation has documented tombs (Figure 2), a not exceptional occurrence for a church, even when referring to the interior space canonically consecrated and ordinarily used for Sunday liturgical synaxis, although such practice was generally prohibited or, when exceptionally allowed, occurred according to specific self-representative schemes. A coveted custom, accepted with suspicion by ecclesiastical authority, which, on multiple occasions, sought to restrain (or at least limit). However, what has been documented in the church of San Vittore remains a very specific case, practiced for probably a short time, although it is very uncertain to pinpoint the exact moment. Nevertheless, there are reasons to circumscribe

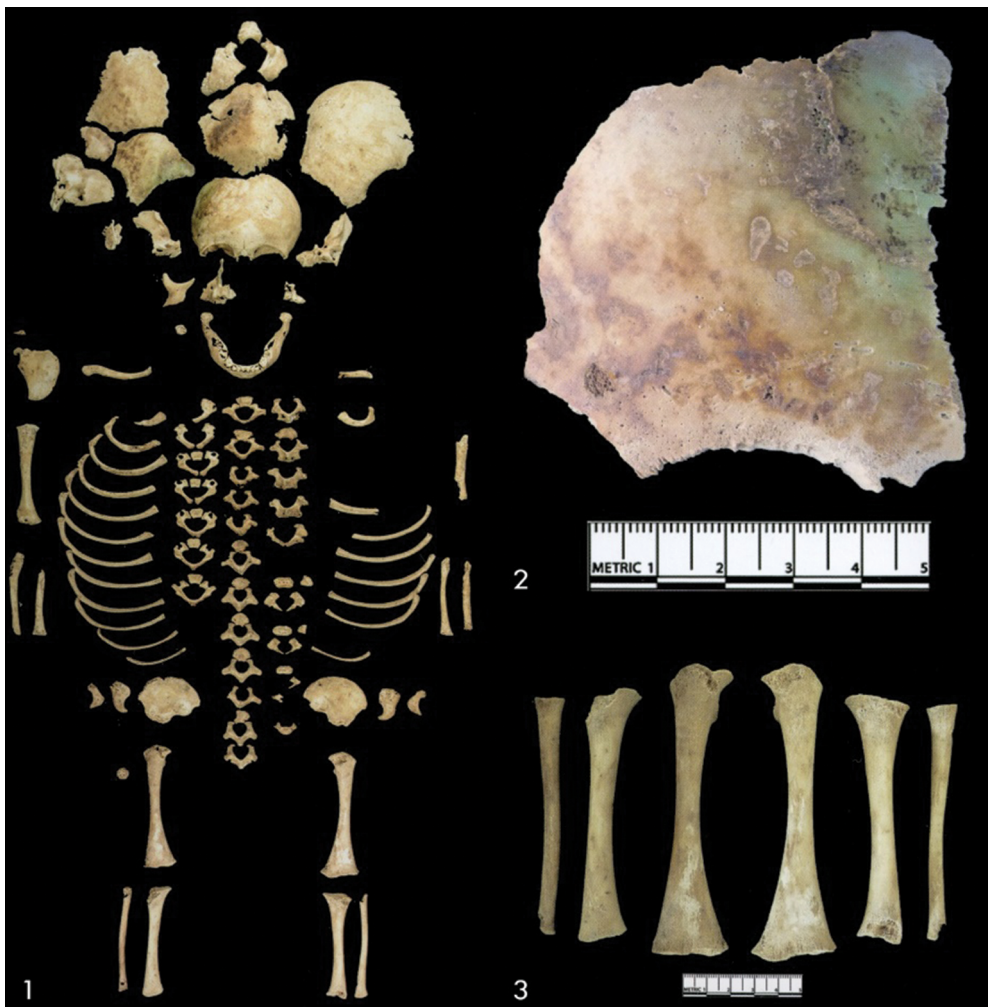


Figure 4. 1) Bones of the non-adult better represented in tomb 10f; 2) Portion of parietal bone with colorations due to contact with copper or copper-containing alloys; 3) Long bones of the lower appendicular skeleton of the subject better represented in tomb 10f showing clear signs attributable to vitamin D deficiency.

it to the late Middle Ages and, in any case, to moments preceding the second half of the 16th century, when funeral rituals and signs of passing changed with a return to the form of dressed burial and the orderly inclusion of devotional elements in tombs that fully contribute to the formation of the funerary deposit. Even the documentation from pastoral visits, which began in 1530 and is usually very attentive to recording present cases, does not mention these tombs, a sign of how they had lost any element of verification.

The five tombs found are simple and indistinct earthen graves, prepared for the burial of individuals within the building in use (Figure 2, Tombs b-f). They

are in the southwest inner corner, below the (not preserved) floor, and with a non-unique depth. The pits, elongated oval, are aligned perpendicular to the north perimeter wall. Four are side by side in a row, while a fifth, identical in shape, type, and orientation, occupies a more detached position towards the center of the nave, about half a meter from the front wall. In the investigation, no relevant interferences were detected, proving that the opening of the pits either occurred in very close times or in the presence of distinctive marks on the floor, signaling and thus safeguarding the position of each tomb, of which, however, there is no trace in the archaeological context. There is then

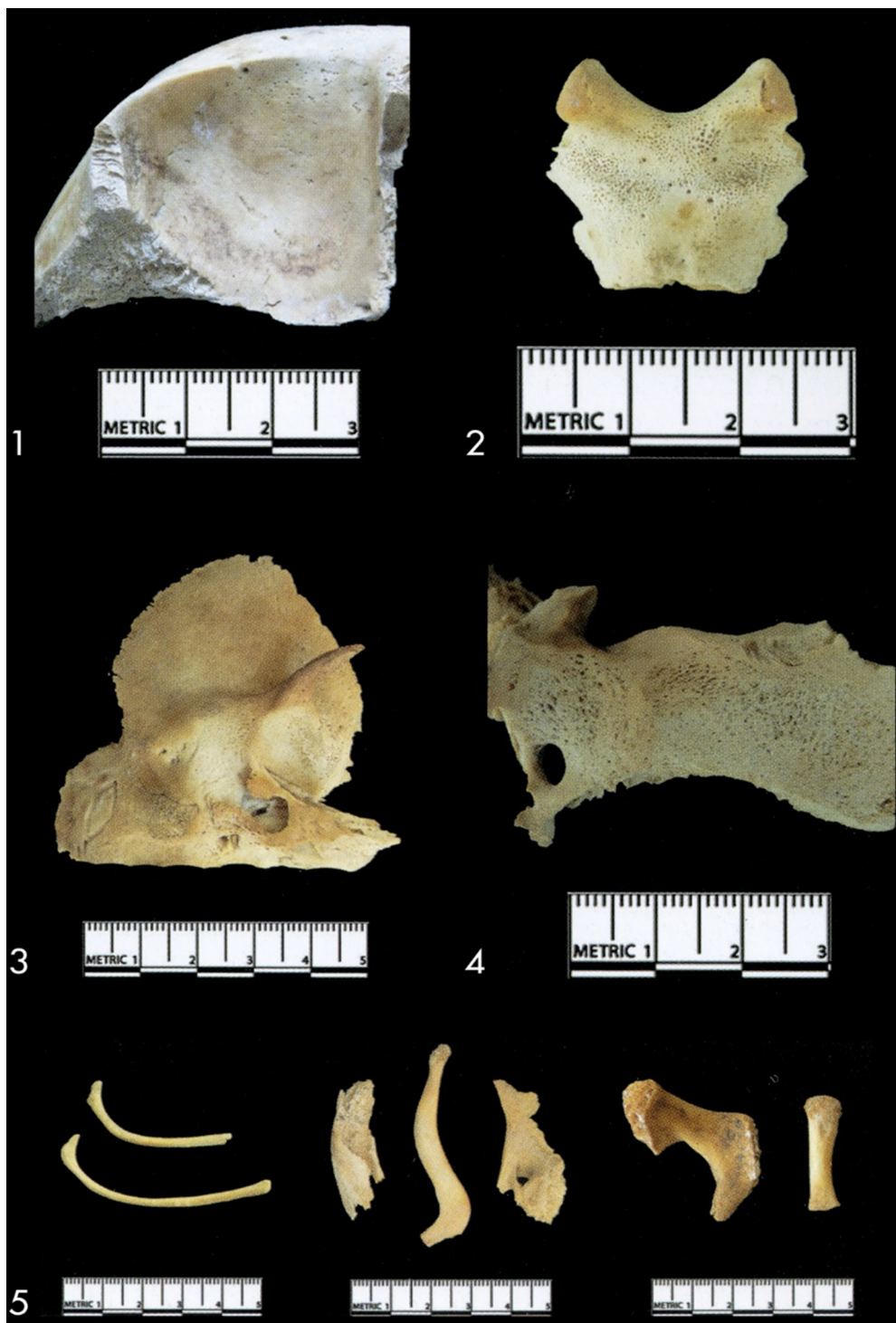


Figure 5. 1) Right frontal bone with slight cribra orbitalia; 2) Pars basilaris with diffuse microporosity; 3) Right temporal bone with diffuse microporosity; 4) Greater wing of the sphenoid with marked microporosity; 5) The three groups of bone elements belonging to at least 3 distinct individuals.

a sixth pit, vaguely rectangular in shape and larger in size (1.60mx0.56m), cut parallel to the foundation of the perimeter without any respect for the pre-existing ones. The shallow depth (-20cm) and the absence of content make it impossible to precisely establish its function, namely whether it also corresponds to an additional tomb, in which case of a later age and with content entirely removed, or if it is something completely different. Only the skeleton of one of the buried individuals has been preserved, intact and in connection (Figure 3). It is an infantile individual laid in a supine position, with the head oriented to the north. For the others, the bone material has disappeared. However, the average size of the pits, which, except for the doubtful one, never or only slightly exceeds one meter in length, suggests that they were prepared for infantile individuals, from a few months to a few years of age. Nothing intentional was deposited with the deceased, and no traces of the use of coffins for burial were detected, to the point that one must think of the simple use of cloths or shrouds to wrap and prepare the bodies for the funeral. Apart from this episode, the interior space has not been further used for funerary purposes: other bodies - according to Christian practice - were buried intensively outside, in a cemetery that the church of San Vittore still maintains in use.

The pathological analysis highlights a rather compromised picture of deficiency and metabolism. Indicators of suffering due to vitamin deficiencies or anemia are the cribrotic areas on the roofs of the orbits (Figure 5, 1). On the basilar part (Figure 5, 2), on the temporals (Figure 5, 3), and on the greater wings of the sphenoid (Figure 5, 4), while signs of inflammation of the periosteum were found on the tibiae, combined with the pathological condition of the lower limbs, which present an abnormal curvature and expanded metaphyses with rarefied bone tissue (Figure 4, 3), are indicative of rickets, a disease known since ancient times and becoming common especially from the last centuries of the Middle Ages. It can be caused by insufficient vitamin D intake, its malabsorption, and inadequate exposure to UVB rays in the first months of life, which therefore - result in a lower supply of calcium and phosphorus to the developing bone. A deficiency that, as a direct consequence, weakens the entire skeleton and its structure with a symptomatic effect in an

abnormal curvature of the bones, especially the lower limbs, as observed in those under examination.

The pathological analysis also shows how the individual in life may have suffered from a vitamin C deficiency, causing another disease, scurvy, which usually manifests itself in the time frame between the sixth and twelfth month. It is very painful, to the point of limiting, if not abolishing altogether in the child, motor skills with a consequent lowering of immune defenses and a slowdown (if not the complete halt) of growth.

While it is impossible to establish the causes that led to the death and if the still scarce knowledge about the lesions caused in the infant's skeletal system by scurvy or rickets does not allow going beyond. It can be noted with certainty that the buried individual had severe vitamin deficiencies, leading to a state of generalized suffering, if not acute, and potentially a reduction in mobility. These conditions, along with a lowered immune response, drastically worsened life expectancy and may have made the body's reaction to potential pathogens that could have been the cause of death difficult.

This study expands our available and published knowledge of research focusing on alpine paleopathology from the late ancient to the Modern era. It specifically investigates the presence of infectious diseases in the region (Larentis et al., 2020; Larentis & Tonina, 2021; Larentis et al., 2023a), diseases resulting from micronutrient deficiencies (Larentis et al., 2020; Larentis et al., 2023b) and those influenced by life histories (Larentis, 2017; Tonina et al., 2018).

Conclusions

The archaeological investigation has identified the floor plan of the place of worship during the construction phase corresponding to the foundation and the ancient construction site. However, it has not been clarified what the sequence was between this phase and the decorative intervention that covered the entire internal wall perimeter with an extraordinary painted cycle. If, however, the timing sequence between the application of the pictorial plaster and the finishing of the construction site was different, as it seems from the

observations made during the restoration intervention, it would involve two distinct moments and, therefore, most likely a different commission that leads to advancing the construction phase, without the possibility, however, of specifying by how much. In the excavation stratigraphy, the chronological reading of this sequence unfortunately lacks direct solution documents, given the removal of the floors and all possible related evidence in the process. The only clue for the construction site remains the fragments of ceramics found in the internal leveling layers subsequent to the construction of the walls and preceding the laying of the floors.

Fragments that belong to high medieval tradition pottery, still very present in the full Middle Ages, between the 12th and 13th centuries, within which the construction site probably took place. The scarcity and absence of other clues speak in favor of use related only to this specific context, while ruling out stable residential occupation on-site, to which the church could have been annexed. The geomorphology of the slope chosen for construction also contradicts this idea, as it was less suitable for hosting stable residential forms compared to what was at the foot, with useful surfaces and lands on the productive side. A collection of alms, like the one found in this church, is attested throughout the Middle Ages and with intensity between the 14th and 15th centuries, almost as if the church from the 14th century onwards - and less so before - was regularly open to worship and attendance by the faithful. In this same period, but without the possibility of a more precise dating, the interior also had a temporary funerary use, very particular for the subjects involved and for the deficiency pathological conditions found in one of the non-adults. Five tombs were found, all of a very simple type and used to bury infants and children of a few years of age in the nave, but no adults. No document mentions the reasons and what may have been the motivations for such a privilege because that is what it is considered, as the norm was that burial in consecrated buildings was a prerogative reserved for priests who served the church or, in very exceptional cases, for laypeople who were great benefactors. The later events of the building concern the addition to the north of a bell tower and a sacristy, the creation of new internal fresco decorations, windows, and new floors (which erase all traces of the tombs, contributing in

this way to their oblivion), the insertion in the 17th century of a lowered vaulted ceiling, and finally, the enlargement of the presbytery with the transfer of the main altar, which could find a better chronological pinpointing in the written sources, as yet unexplored in this regard.

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