

# The history of the walls of the Acropolis of Athens and the natural history of secondary fracture healing process

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## Abstract

During its long and adventurous history, the Acropolis of Athens has been a site of many dramatic events. It suffered its most disastrous destruction during the Persian wars. Under the command of King Xerxes, the Persians invaded Athens and ruined the Temple of the Parthenon and the walls of the Acropolis. After their victorious sea battle at Salamis, the Athenians, led by Themistocles, returned home and tried to repair the damage. Their priority still was to defend their city by restoring the walls of the Acropolis. Materials of all kinds were salvaged from the ruins of the Acropolis and used for an immediate reconstruction of the walls. Later, when the Athenians became the leaders of the Greek world, it was decided that the walls should be rebuilt in a proper artistic way. Themistocles suggested that a small section of the walls, which had formerly been a part of the urgent restoration, should remain in place so as to remind the citizens of this historical event. This is a characteristic example of the biological and mechanical adaptation of fracture callus to musculoskeletal function. After a period of urgency with the fixation of a fracture by means of a primitive secondary callus formation, the broken limb gradually returns to its usual function. Increased mechanical loading enhances the remodelling of the callus and the replacement of woven bone with lamellar bone.

**Keywords:** Walls of Acropolis, History of Medicine, Acropolis of Athens, Fracture Remodelling

## The history of the rebuilding of the walls of Athens

The Persians invaded Greece from the north in 480 BC with a huge army commanded by King Xerxes. The Greeks initially tried to stop the Persians' advance at the narrow pass of Thermopylae but finally the 300 specially selected Spartans and their leader, Leonidas, were slain and died heroically. The Persian army marched south and soon reached the city of Athens. When the Persians invaded many Athenians abandoned their city. Women and children fled to safety, mainly to the islands of Salamis and Aegina and to Troezen on the Peloponnesian mainland. The men remained on their ships to consider how best to face the enemy. In the meantime, the Persians captured Athens and destroyed the walls and temples and almost all of the houses in the city. The few houses which remained intact were used to accommodate their generals. The ancient temple of the Parthenon and the walls of the Acropolis were ruined.

Finally, the city was set on fire and everything in it was totally destroyed. The Athenians remained on their ships and drove the huge Persian fleet to the narrow stretch of water between the island of Salamis and the Attica mainland. The glorious sea battle of Salamis was the beginning of a series of defeats of the Persian army. King Xerxes left Greece after this disaster but the Persian army remained close by for another year awaiting an opportunity to seek revenge. At the battle of Plateae in 479 BC and the following sea battle of Mycale, the Persians were totally defeated.

Gradually the Athenians returned home, finding on their return an empty and ruined city. For their safety it was of paramount importance that the walls of the Acropolis and the walls surrounding the city should be rebuilt. Themistocles, the leader of the Athenians, ordered that reconstruction works proceed as quickly as possible. This procedure became more urgent as their rivals, the Spartans, asked them diplomatically not to reconstruct the walls and in the event of a future Persian invasion to seek protection in the Peloponnese.

Thucydides<sup>1</sup> and Plutarch<sup>2</sup> give a detailed description of the way in which the Athenians rebuilt their walls without the Spartans' knowledge. The materials used in the reconstruction included pieces from the mined buildings, parts of the columns from the temples, bricks and generally any

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available materials. Thucydides describes the operation thus:

*"... but to continue their efforts until the wall is raised to the necessary height. And everybody in the city including women and children should help in building the wall without sparing any public building useful to the construction, but to use everything..."* (Thuc. A,89).

*"...in this way the Athenians rebuilt the city and walls in a short time. Because the foundations consist of many kinds of stones and not quarried stone, and because the materials used were those convenient at the time, even columns from graves and gravestones were incorporated into the walls..."* (Thuc. A,93).

After the urgent construction and when Athens became safe and started to prosper, the walls of the Acropolis were rebuilt in an artistic way. This time the rebuilding was carried out over a considerable period of time, as there was no reason for urgency. According to tradition, a section of the northern part of the walls, exactly above the Agora of Athens, was left as it was originally constructed and into which had been incorporated vertebrae from the old temple of the Parthenon (Fig. 1).

It is said that this peculiar and visible remnant was deliberately left untouched as a reminder to the citizens of the disasters suffered as a result of the Persian invasion.

### **The teleology of the natural history of fracture healing**

Fracture healing is a dramatic event in the life of a vertebrate. A simple fracture can easily cost an animal its life and this outcome is not uncommon in nature. The difficulty in restoring initial locomotion mainly depends upon the efficacy of the fractured limb in enduring the increased mechanical loading<sup>3</sup>. Restoration of pre-existing bone strength is in any event an extremely time-consuming

process. Essentially, painless movement is temporarily suspended by a natural splinting of the fracture site and the initial formation of external callus. Mechanical insufficiency is partially corrected by eccentrically produced callus, avoiding the inter-fragmental space and increasing the outer diameter of the callus, e.g. with a bulky callus. The external callus is composed of woven bone, cartilage or connective tissue and is rather soft in the initial maturing phases<sup>4</sup>.

As maturation advances the local strains are reduced and osteoblasts are enhanced to produce harder bone tissue. The external callus is an urgent process and must be replaced by lamellar bone strong enough to endure full musculoskeletal function. The remodelling process is initiated in the intermediate stages of fracture repair and it depends upon the maturing of the vascular network of the callus.

The vascular tissue brings pre-osteoclast and osteo-inductive factors differentiating the stem cells to osteoblasts. The woven bone is gradually replaced by lamellar bone and the whole remodelling process results in a structure that is mechanically competent and at least as strong as the original intact bone<sup>5</sup>. The outcome of fracture healing is therefore initially the urgent restoration of the connectivity of the fractured bone and the neutralization of the excessive mechanical strains at the site of the fracture, but not the anatomical restoration.

The urgency of this process can be achieved with the production of external callus, which works as a natural splint. Mobility at the site of a fracture promotes the endochondral ossification and produces huge external callus. The behaviour of the stem cells depends upon the local condition of stability and vascularization. Mobility associated with impaired callus vascularization leads to the formation of cartilaginous callus. As stabilization is achieved, the external callus matures and is transformed to bony callus. This transformation is crucial to its future. If excessive mobility continues for a long period callus induction is exhausted resulting in hypertrophic non-union.

On the other hand, if callus formation has sufficiently progressed, the final union is secured. For many clinicians, the development of woven callus is considered to be the completion of the fracture repair phenomenon. This is by no means correct.

At this stage a fracture is still in the first stages of its remodelling and for a long bone at the site of a fracture, a high bone turnover will continue for many years. The teleology of fracture remodelling is the achievement of optimal mechanical conditions, usually similar to the pre-fracture status.



**Figure 1.**

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