

## The Historical Background of Plaster Cast

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### Abstract

The pivotal role of plaster of Paris (POP) cast as an immobilization tool to promote healing in complex and/or other types of fractures is irrefutable. We clearly know that Antonius Mathysen extensively applied plaster cast during Crimea and/or other wars and reportedly saved thousands of lives. However, the exact origin of using POP in orthopedic cast is yet to be clear. In his famous report from Bandar-e Rig, a city in Iran, William Eton paved the way for the conclusion that POP cast might have originated from the Persian Empire. In this paper, we provide more supporting evidences which make the aforementioned claim more probable.

**Keywords:** Persian Empire, plaster of Paris cast, William Eton

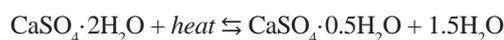
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Casting, as a non-surgical method of immobilization for fractures, has been applied for a long time to reduce multifarious fractures. Splinting is usually the proper technique for simple and/or stable fractures; however, casting is preferred for definitive and/or complex fractures. Casting and splinting provide a stable condition for the injured tissue to trigger the healing process and protect it from infection and other complicated situations associated with fractures. However, they might afflict patients with some adverse effects, such as compartment syndrome, infection, dermatitis, and joint stiffness. The litheness and ease of application of splinting have made it the prevailing method among orthopedists; however, robustness of casting provides a more desirable condition to promote healing, making it the first unrivalled choice in complex fractures.<sup>1,2</sup>

The first recorded use of splinting for fixation of fractures dates back to ancient Egypt: the well-known Edwin Smith Papyrus underscore the wide use of bandages and fibers derived from myriad of plants, more specifically Bamboo, to stringently immobilize fractured organs and expedite the healing process.<sup>3,4</sup> Romans took advantage of splinting methods using various bandaging techniques, and they cemented bandages with adhesive substances, such as resin, wax, starch, cerate, lard and so forth to optimize its stiffness for the betterment of fixation.<sup>5-7</sup> Apparently, both ancient empires were thoroughly acquainted with disinfectant substances, such as honey and alum since they consummately smeared afflicted organs with them to prevent any possible infection.<sup>3-7</sup>

As mentioned above, plaster cast, and more specifically plaster of Paris (POP) cast, is irrefragably preferred over splinting in more serious fractures due to the former's sturdier fixation of injured organs; however, contrary to its firmness, its history is downright controversial.<sup>8</sup> Regardless of the origin of plaster cast, based on the recordings, nascent plasters mainly comprised of two

basic substances in their variegated formulations: Calcium sulfate and calcium oxide. Avicenna and Rhazes applied calcium oxide, usually extracted from lime of sea shells, in conglomeration with egg whites as a hydrating agent, to produce a versatile paste easily wrapping up fractured organ and quickly turning into a stiff material that can immobilize the organ.<sup>4</sup> Abu Mansur Muwaffaq developed a unique method which is nowadays renowned as gypsum Cast (POP cast).<sup>5</sup> In this game-changing method, gypsum stones, which mainly consist of hydrated calcium sulfate, were heated to produce a fine gypsum powder, or anhydrous calcium sulfate (below equation). In the next step, calcium sulfate would be hydrated gradually with water and poured around the fractured organ—the hardening process would start in an apropos manner which provided enough time to shape the casting box and its appurtenances.<sup>3-5,8</sup>



By heating gypsum ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) to around 150°C, a white powder is obtained which is anhydrous calcium sulfate or Plaster of Paris. The term “Plaster of Paris” was proclaimed from a mine in Montmartre, near Paris; however, this process is exactly the same as the process which prevailed across ancient Persia.<sup>9</sup> This chemical process is reversible which means that by hydrating Plaster of Paris, it will harden, manifesting an appealing characteristic for fixing an injured organ.

### When was Plaster of Paris introduced as the main ingredient of casting?

Conspicuously, due to scantiness of historical evidences, we can hardly adduce Muwaffaq's method as an established, widely-used reducing method since we cannot trace the trend in which the nascent molding cast has been sublimed into admired POP Cast which has saved thousands of lives during the world wars.<sup>8</sup> However, we can certainly trace the prodigious advancement of POP cast from the time it was introduced, if we admit that the first record pertains to Muwaffaq around 975 A.D., to the time of William Eton, incumbent Britain ambassador at Basra (city in Iraq), who has blatantly expounded on Persian Muslims unique

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method of reducing complicated bone fractures.<sup>3,8</sup> Recently, we came across a wonderful historical evidence which can be the missing link between nascent casting method and the advanced method reported by Eton. The method is clearly portrayed in a historical Persian book, *Badaye-ol-Vaqaye*, the masterpiece of Zeinoddin Vasefi. In this book, Vasefi clearly delineated zeitgeist of Herat (city in Afghanistan) from the late Timurid Empire to the early Safavid dynasty. Vasefi clearly depicted a “*Choobazi*” competition, a ceremonial fighting in which competitors try to fight and defend each other using wooden sticks (Figure 1).<sup>10</sup> The competition takes place between a “*Pahlevan*”, a rank assigned to a wrestling champion who has mastered not only wrestling but moral practices, and a prince during the ruling of Sultan Husayn Mirza Bayqara, Timurid ruler of Herat from 1469 to 1506.<sup>11</sup> Since Eton reported his observation in 1795, Vasefi’s depicted method can be clearly assumed as the antecedent version of POP cast and/or casting method of Eton.

Vasefi conspicuously portrays the aforementioned *Choobazi* competition in which the *Pahlevan* furiously beats the prince during the competition which elicits horrible complex fracture of prince’s limb. He then proceeds to recount how an adept physician promptly reduces and then casts his leg. Vasefi’s text is reproduced below:

“For treatment of his leg, Ostad Sheikh, the physician, ordered to bring gypsum, then producing ‘*Doughaab*’ (a suspension of gypsum in water) from it. Then, he ordered to dig a trench the size of his leg and put his broken leg in it while he was sitting on the ground. The physician commenced reducing the bones from ankle then poured *Doughaab* on it to cover the distal part of the leg. After that, he reduced the rest of the proximal part and promptly poured *Doughaab* on it to thoroughly cover the leg. After taking care of it for forty days, the physician broke the casting box and the prince’s leg was downright healthy”.<sup>11</sup>

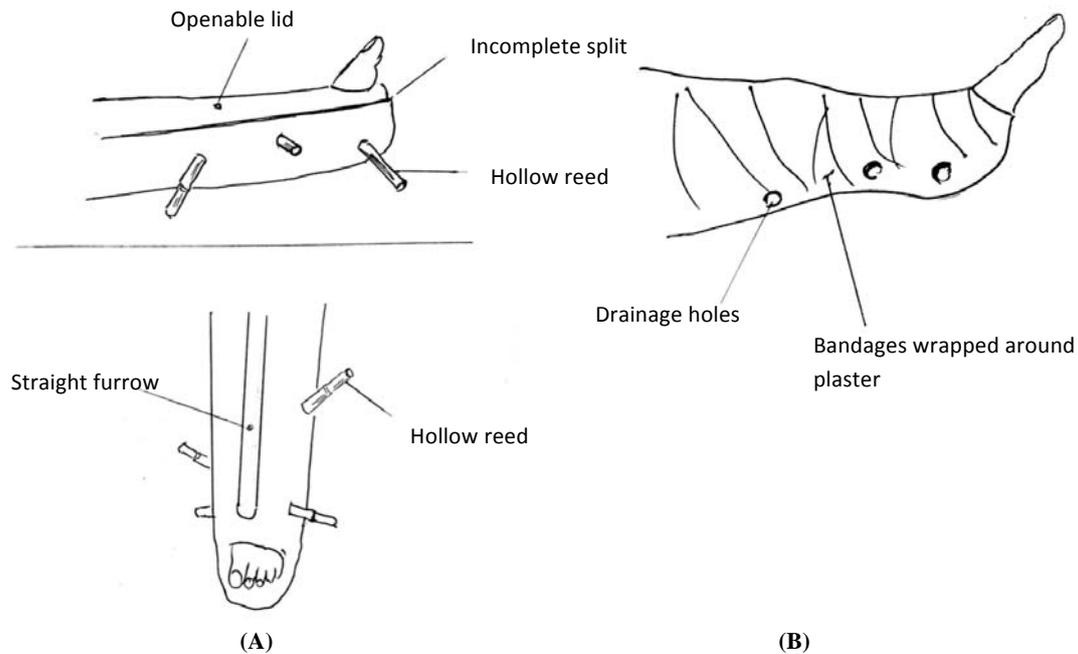
The second and more advanced method pertains to Eton’s depiction of casting. William Eton reportedly has portrayed

two distinguished, marvelous methods of immobilization which he conceded were far superior in efficacy and practicability in comparison with the reducing method prevalent in Europe of that time. In the first case, Eton delineates a complicated, horrendous fracture of a limb which was adeptly fixed and treated without ambulation or any appreciable complication. In the first step, the fractured limb was laid on an oiled mat which played the role of a useful cover helping the bonesetter to conveniently patch up the shattered bone together, and, in addition, would not let the molded plaster of Paris cling to the ground. Subsequently, molded Plaster of Paris was poured around the limb up to the middle to form a kind of bed for it. Concomitantly, some hollow reeds were placed through the plaster for the purpose of draining off harmful fluid that can hinder healing and afflict the organ with baneful infections. After a short time, the first layer of plaster became hard and the second layer was poured around it to form a consistent plaster box. In the next step, a straight groove was instantly carved out on the upper surface of the cast; the groove would be filled with seemingly vulnerary fluids to gradually diffuse through the wall of the cast and reach the limb. Then, the upper part of the cast was precisely cut incompletely to form a kind of exploitable lid which can be cut out easily in the case of urgency and/or inspection. The whole cast was belted around the patient’s waist with a piece of bandage previously embedded inside the cast (Figure 2). The extent to which the forgoing reducing method was developed portends that this method has been deeply entrenched in the Persian Empire for a long time.

The second method portrayed by Eton pertains to his trip to the Turkish Empire where he witnessed another horrible limb fracture; the bonesetter placed the limb in a wooden plaster box and poured molded Plaster of Paris into it. During the process of rigidifying, the bonesetter might place some wooden stick through it and remove them later. The holes which remained could serve as drainage canals. Bandages were also wrapped around the stiffening cast to form it decently and/or make it more lightsome



**Figure 1.** Picture of “*Choobazi*” ceremony in which fighters symbolically fighting each other while others playing music and/or watching the encounter. *Choobazi* is an existing tradition which ceremonially implement across Iran.<sup>10</sup>



**Figure 2.** **A)** Shows the thoroughly advanced gypsum cast which Eton has delineated in his letter to his friend, Matthew Guthrie. In this letter, Eton clearly depicted how adeptly Persian, Muslim's bonesetters reduced a complicated fractured limb with their consummately advanced casting apparatus. In figure A (above), the openable lid has been scored on the casting mold that can be usable at the case of emergencies. In the below, the groove is depicted which is above the gypsum cast, Muslims used this groove to pour antiseptic liquids to it. Hollow reeds were embedded inside plaster mold to form a drainage path to extract harmful liquids from inside cast; **B)** Shows the second portrayal of Eton from Turkish empire which is virtually similar to his first observation. However, in this plaster cast, bonesetters applied bandages to fixing mold around limb, and instead of hollow reeds, suitable holes curved out to facilitating drainage process.<sup>3,8</sup>

and moveable. Ardent spirits were splashed over the plaster as disinfectant substances.<sup>3,8</sup>

The two aforementioned methods which mostly seem to stem from a single advanced method immediately disseminated throughout European countries. With some modifications, it was introduced and vehemently applied by Antonius Mathysen; he widely applied it by embedding Plaster of Paris inside cotton bandages which made it extremely handy and practicable during the Crimean War (1853 – 1856).<sup>4</sup> As time passed, other modifications, such as adding binders have been made on POP cast; however, emergence of thermoplastic-based casting materials partially supplanted Plaster of Paris application in reducing fractures.

Contrary to the trend of development of splinting technique and materials applied by Egyptians and Romans, the history of casting is not limpid enough. From the Muwaffaq's concoction of incipient plaster mold to the highly-developed POP cast widely practiced by bonesetters and/or physician in Muslims' empire, virtually an eight-century period of time, it seems that Muslims were trying to develop their casting method. Vasefi's depicted method is considerably more advanced and practical than Muwaffaq's, and then there is Eton's depicted method which is comprehensively improved in comparison to Vasefi's reported method. The colossal extent of advancement of POP cast at the time witnessed and reported by Eton portends how deeply this method was inveterate and prevailing among Muslim physicians. The plaster cast equipped with drainage ports, openable lid, and predesigned furrow filled with disinfectant liquids, all patently show that this method has been practiced and developed for a long time in Muslim countries during the Islamic Golden Age.

In addition to the extent to which the plaster cast of Muslims was advanced and developed, some other meaningful evidences are available which can be adduced to ascribe the discovery of plaster cast to Muslims. At the time of the Islamic Golden Age, Iran was the greatest and most prominent part of it which nurtured myriad of preeminent scientists and/or physicians serving the whole empire. Iran held one the largest mineral resource of gypsum across the world which was extensively used in prominent Iranian architecture. Iranians were consummately acquainted with the superb characteristics of gypsum which made it a suitable material for their splendid architectural structures. Although the most florid period of application of gypsum pertains to structures and decorations of Qajar dynasty, the splendid mould plaster decorations can be seen in ancient structures remaining from Elamite and Achaemenid periods.<sup>12</sup> These splendid mould cast structures clearly indicate the pivotal role of gypsum in Irano-Islamic architecture and how deeply they were familiar with gypsum characteristics.<sup>9</sup>

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