

## New image processing of the Turin Shroud scourge marks

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### Abstract

A preliminary study presented at Columbus Conference on the Turin Shroud in 2008 identified three different types of scourge marks on the body image of the Shroud. By means of a new kind of image processing, the characteristics of the three marks have been better highlighted and the results are also verified through comparison with signs experimentally produced by different kinds of whips on a proper carton paper. It experimentally results that imprints similar to those observed on the Turin Shroud can be obtained if at least two whips are used: a bunch of flexible rods and a flagrum.

**Keywords:** Scourge marks, bloodstains, Flagrum, carton paper.

### 1. INTRODUCTION

The blood traces found on the Turin Shroud (TS) attracted the attention of many sfighcholars since 1898, when S. Pia made the first photograph. These traces have been analyzed by P. Vignon in 1902 [1], P. Barbet in 1937 [2] and others. In 1978, during the STURP (Shroud of Turin Research Project) campaign, J. H. Heller and A. D. Adler [3], and independently P.L. Baima Bollone [4] established that the red traces are stains of human blood, transposed on the cloth by fibrinolysis [5, 6]. The bloodstain characteristics are difficult to fake and until now every attempt to fully reproduce them in a copy of the TS has been vain [7]. Numerically, the most abundant bloodstains on the double body image of the TS Man are those caused by scourging [8]. These marks cover almost the entire body surface, but in some areas of the frontal image they are fainter and it is not simple to detect them using naked eye observation. On the contrary, in other areas, as back and buttocks, they are more evident (thanks to the weight of the corpse acting on the TS), frequently appearing as small round double imprints connected by a short straight trail, with a shape similar to a dumb-bell. They have been defined "laceration-and-bruise wounds" by various forensic pathologists [9, 10].

In Fig. 1 the most evident bloodstains on the TS caused by scourging are evidenced in red. Excluding some signs of dubious origin (for example one on the head of the back image) 372 bloodstains can approximately be counted (159 on the front image and 213 on the back image). If the image is carefully examined, it can be noticed that the dumb-bell shaped marks are not the only kind of scourge trace, as they are joined and often somehow mingled with more evanescent scratches similar to elongated furrows. The scourge marks frequently cross each other and have been subsequently overlapped by other blood marks, like the so called "blood belt" or the outflows from the wrists.



**Figure 1.** The most evident bloodstains relative to scourge marks, evidenced in red.

This fact indicates that they preceded other tortures in the temporal sequence of the execution of the TS Man.

## 2. SCOURGE MARKS DETECTION

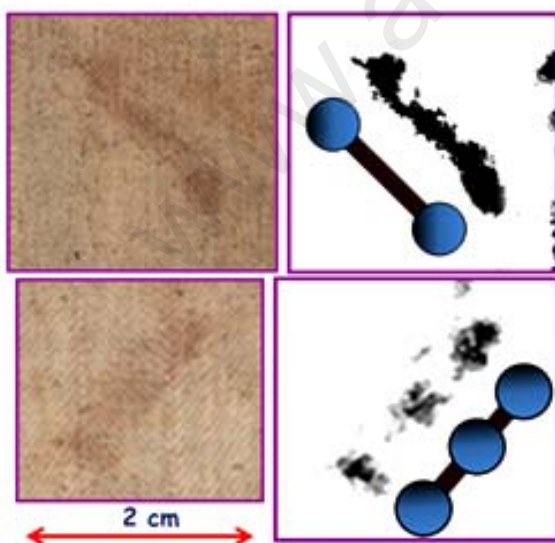
In a previous work [11] three kinds of scourge marks had been preliminarily identified through image processing on high resolution TS images.

The first kind (Type 1) is the dumb-bell shaped mark (Figs. 2, 3); more evident and easily recognizable, it is referred to the damage of *Roman Flagrum* ending parts [8, 12] and its shape is comparable with that of a first century Roman whip.

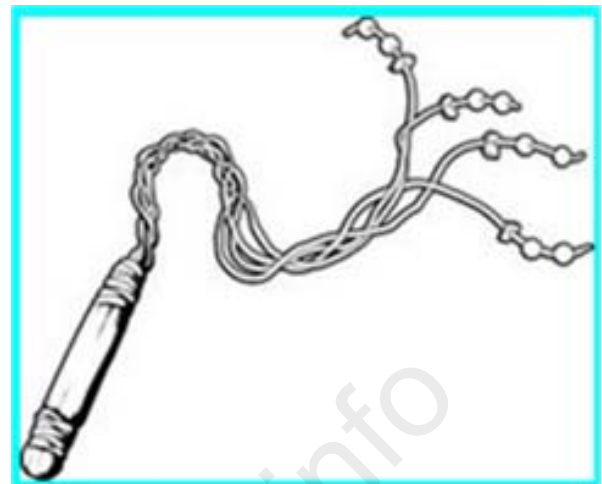
The second kind (Type 2) is the most abundant scourge mark, but it is too faint to be correctly defined observing the TS only by naked eye. It consists of large striped bands (10-15 mm wide) of varying length (somewhere reaching 7-8 cm, for example on shoulders and upper back area) that look like deep scratches (Fig. 4).

The third kind (Type 3) is more rare (it occurs less than 15 times) and much more faint. It is found on legs, calves and close to the ankles in both frontal and dorsal image. It consists of a fan composed by 3 - 4 thin curved stripes (Figs. 6, 7).

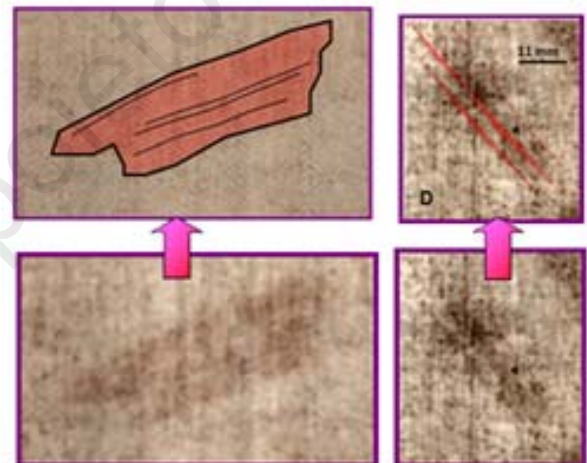
According to Ref. [11] it was not possible to link Type 2 and Type 3 directly to the flagrum, and a different torture instrument had to be taken into account for explaining these scourge marks. Type 2 was thought to result from the damage of a whip made of thin, flexible rods, like the famous "Virgae" used both as torture instrument and as a symbol of power by the lictors. Type 3 was probably a sort of "deformed Type 2", resulting from the wrapping of Type 2 mark around the thinnest parts of the legs, around the calves and the ankles.



**Figure 2.** Two blood marks caused by the Type 1 scourge with the relative reconstruction of the shape of the torture instrument.



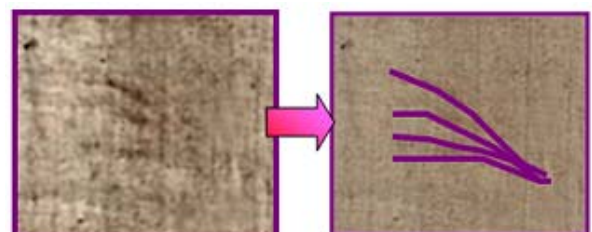
**Figure 3.** Reconstruction of the shape of the torture instrument for Type 1 scourge marks.



**Figure 4.** Two blood marks caused by the Type 2 scourge with the relative reconstruction of the shape of the blood mark in red.



**Figure 5.** Reconstruction of the shape of the torture instrument for Type 2 scourge marks.



**Figure 6.** Blood mark caused by the Type 3 scourge with the relative reconstruction of the shape of the blood mark.



**Figure 7.** Reconstruction of the shape of the torture instrument for Type 3 scourge marks.

The problem of the previous image processing was mainly due to the use of different procedures, capable to enhance either Type 1 or Type 2 and 3 but not all three types together. The filters cyclically used to highlight Type 1 scourge mark often erased other kinds of noise eventually present in the same area, making not easy the identification of the relationships among the three Types.

Type 2 mark was already noticed by some Authors, for example G. Ricci [12], who charged them to the graze left by flagrum straps. In this perspective, each Type 1 mark have to be linked to a Type 2 mark, that should somehow be the "tail" of the dumb-bell shaped imprint. On the contrary, Type 1 appears independent from Type 2 and Type 3, and the experimental result confirm this, as will be shown: Type 1 terminations did not have any tail or graze attached, nor Type 2 marks end in a Type 1 sign.

The overall appearance of a random overlap between the two kinds of scourge marks has been in few cases confirmed by the previous image processing, but the problem was still unsolved for the great majority of scourge marks [11].

An image processing that could enhance both types together, without losing information, was needed and this was the first task faced in the present work.

Another way to solve the problem of the relationships between the different scourge marks could be found in the experimental reproduction of the imprints, using instruments similar to those hypothesized, and in the comparison of the results with both natural TS image and processed areas.

### 3. IMAGE PROCESSING

#### 3.1 Construction of a "clean" image

A high resolution image of the TS scanned at 300 dpi [13] has been used in this new processing performed with CS 4 Adobe Photoshop®. All signs referring to fold, water stains and clots of unknown origin have been reduced/smoothed using 3 particular filters:

1. "Noise reduction". It smoothes the image acting on the RGB values of proper areas around each image pixel.

2. "Clone-stamp". It is a filter that copies a selected area into another. For folds and stains other than blood stains this filter has been used by copying a clean area immediately close to the flaw to be corrected.

3. "Correction brush". This filter corrects the selected area by "dragging" pixel of the surroundings; it automatically copies the properties of the closer pixels and further smoothes the flaw.



**Figure 8.** TS double image after cleaning process.

The image obtained is reported in Fig. 8. It was the starting point for all successive processings illustrated below.

#### 3.2 Processing of selected areas

A two step processing has been applied on selected areas (back, buttocks and legs, and calves for the dorsal image and chest, quadriceps and shins for the frontal image) in order to identify the different scourge marks, and giving the possibility to single them out.

D) The first step was undertaken to clearly identify all Type 1 scourge marks. An image processing using false color had been used to highlight only Type 1. The results have been obtained in different steps:

- 1- On the clean image, a new layer has been created;
- 2- Application of the filter "diffusion". This filter operates by transferring the color of the most abundant pixel into those pixels having a similar tone but which are numerically inferiors. The result is an almost complete deletion of the fishbone texture of the linen;

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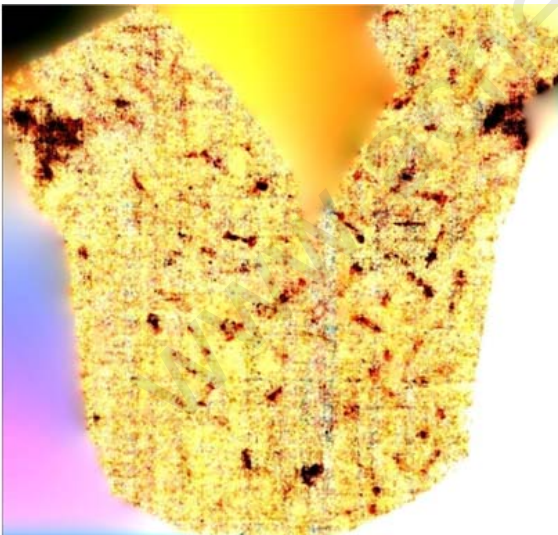
3- Application of a "contrast mask". This step comprises an iterative enhancing of the difference between RGB tones, leading to an increase of the darker and lighter shades. At this point all scourge marks are much more visible and the background is homogenized;

4- Iterative application of "Eraser Classic" filter: this free-download filter allows the deletion of a single selected RGB value. It has been repeatedly applied in order to erase all those tones not directly related with the scourge marks, for example the bluish and the greenish colors due to jpeg transformation of the image. It has been also used to erase the colors referring to Type 2 and 3 scourge marks that at this stage we did not want to keep.

5- The processed level has been then exported on a white background and another free-download filter, "Solidify C", has been applied. Solidify C turns an image layer entirely 100% opaque. It reveals partially transparent areas, and it can even help to repair the corrupted transparency channels. It smears the outer edges of a shape for a harder look. This final step has been done to enhance the shape of Type 1 pattern on a uniform background.

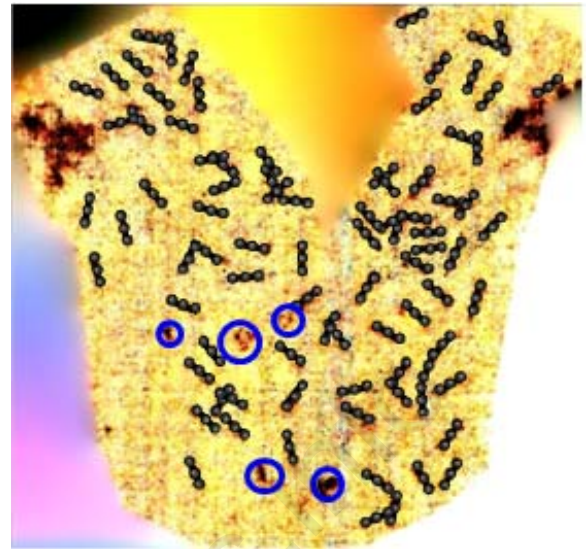
The results are shown in Fig. 9. Each Type 1 has been marked with a symbol of the dumb-bell shape end of the flagrum, and all they constituted a further new level that was possible to export and apply elsewhere (Fig. 10).

Only few areas (blue circles) of great color intensity were not considered, as their shape did not fit the dumb-bell mark typical of all other signs. Their origin will be explained later on.



**Figure 9.** Detail of the back of the TS body image after processing to evidence Type 1 scourge marks.

**II)** The second step of the processing had the aim of enhancing both Type 1 and Type 2 scourge marks contemporaneously. Starting again from the clean image of Fig. 8, a processing sequence similar to that already described has been applied until point 3.



**Figure 10.** Type 1 scourge mark layer evidenced from the image of Fig. 9.

The contrast mask have been again applied by selecting a high contrasting factor (more than 250%), a medium pixel size (around 50%) and a null level threshold. The first two values are indicative and have been varied for each of the other selected areas for a small interval (+ 10). Results can be seen in Fig. 11.

Type 1 scourge mark layer obtained from the previous processing have been overlapped to this new image, in order to make easier the distinction between the two Types (Fig. 12).

Once that Type 1 have been located, it was simple to detect Type 2, as it can be seen in Fig. 13.



**Figure 11.** Type 1 and Type 2 scourge marks visible after graphic processing.

Type 1 is characterized by a more defined and short shape and it has the darkest RGB values; Type 2 instead is

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lighter and in most of the cases it does not have well defined contours. In particular it has to be noticed that Type 2 do not ends in a Type 1 mark, confirming that the two signs are not related each other and the interpretation of Type 2 as the graze of the flagrum leather cords is untenable.



**Figure 12.** Type 1 scourge mark level applied to Fig. 11.

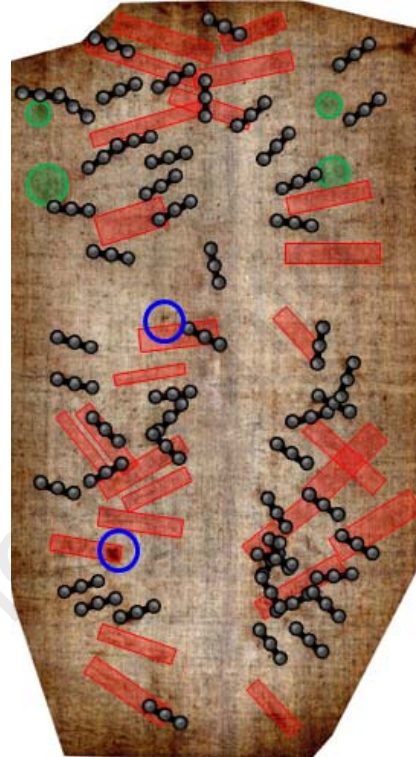


**Figure 13.** Enhancing of Type 2 scourge marks as can be deduced from Fig. 12.

If the two Types are not related together as different parts of the same whip, they should be interpreted as the result of two distinct torture instruments.

Similar image processing has been applied to buttocks and legs and to calves (back body image of the TS, Figs. 14 and 15). In all cases, other bloodstains that could be classified neither as Type 1 nor as Type 2 have been found

(blue circles, see Figs. 12, 13, 14, 15). In buttocks area symmetrical stains not referred to scourging are highlighted in green (Fig. 14).



**Figure 14.** Detail of the back of the TS body image in correspondence of legs after processing.



**Figure 15.** Calves area. Type 3 marks have been highlighted in violet.

Similar image processing has been applied to the frontal image. Here both Types are less evident and their color intensity is lighter, so a stronger contrast has been used in the "contrast mask filter". Results are shown in Fig. 16.

Detection of scourge marks, even after image processing, is difficult in quadriceps and shins areas, most probably because the contact between the body and the linen sheet was scarce or absent [14].

Type 1 and Type 2 scourge marks are visible together with Type 3 (violet layer) in Figures 15 and 16. It was previously supposed that Type 3 derived from the deformation of Type 2 caused by the wrapping of the flexible rods around the calve. Type 3 marks, however, are quite different from Type 2 ones and their origin is still debatable.

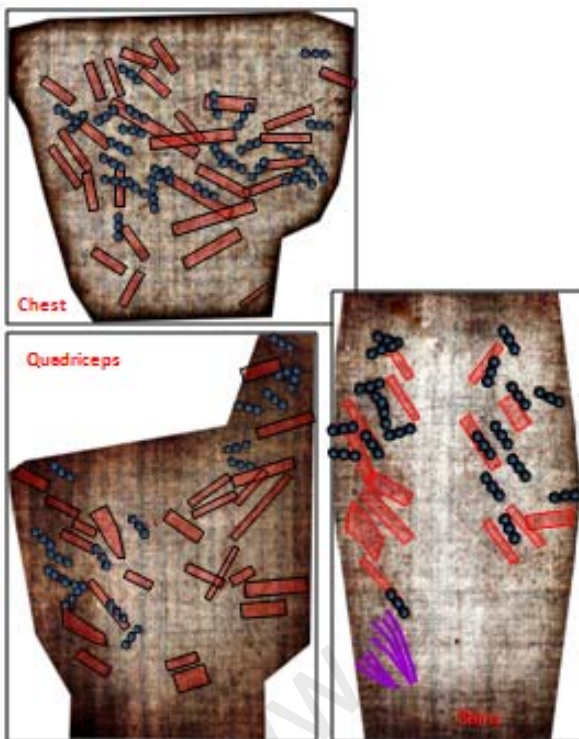


Figure 16. Type 1, Type 2 and Type 3 scourge marks in chest, quadriceps and shins.

#### 4. EXPERIMENTS

Two experiments have been performed with the aim of reproducing the shape of the scourging marks visible on the TS. For both experiments a carbon paper has been placed on a white sheet, attached to a vertical cylinder having a diameter of 60 cm. To simulate muscle and skin, a cotton sheet has been put between the cylinder and the white sheet, and another cotton sheet has been added over the carbon paper, as reported in Fig.17.

##### First experiment: only flagrum.

About 50 blows were delivered with the home made

flagrum replica of Fig. 18 having three leather straps armed with dumbbell-shaped lead spheres.

The results of this first experiment are visibly comparable with those obtained by P. Vignon [15]. As it can be seen in Figures 19 and 20, overlapping zones of whipping generate blurred patterns, as those indicated in the blue circles of Figures 12, 13, 14 and 15, but only the metal spheres leave a mark, whereas the leather straps do not.

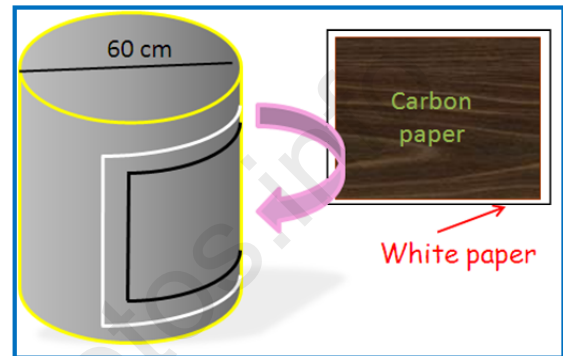


Figure 17. Experimental apparatus used to reproduce the shape of the scourge marks.



Figure 18. Flagrum replica used for the experiments.

##### Second experiment: rod and flagrum.

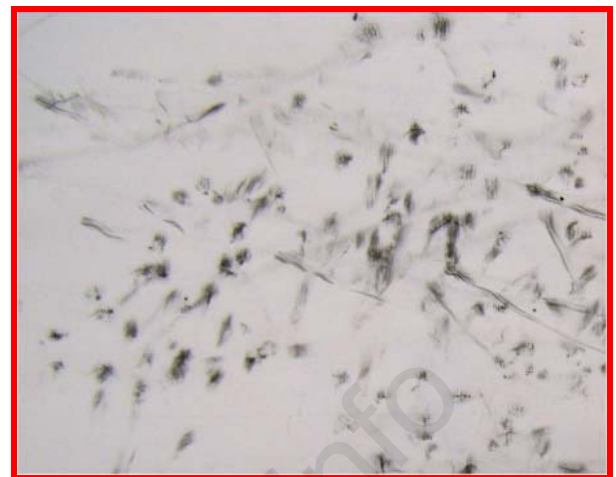
In the second experiment, the cylinder was hit by about 50 lashes delivered using a flexible pear rod (having a maximum diameter of less than 1 cm and thinning progressively at the end) and, subsequently, by about 40 lashes of the flagrum replica of Fig. 18.

The results are reported in Figs. 21, 22 and 23. Note that the elongated marks left by the rod are casually overlapped by the dumbbell shape imprints relative to the flagrum replica.

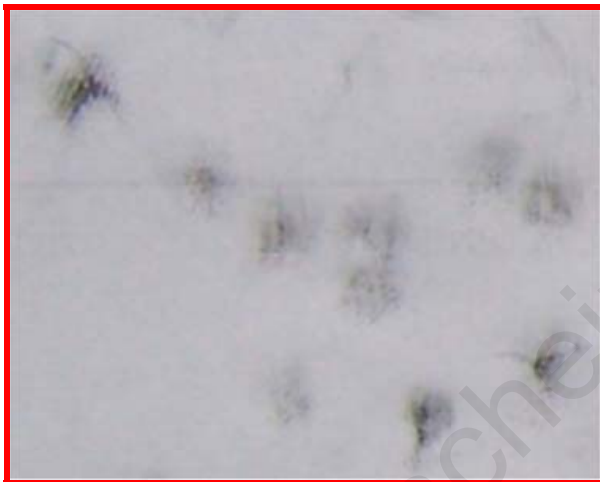
Patterns generated using only the flagrum replica (Figs. 19, 20) are quite different from those observed on the TS (Figures 11, 14, 15), whereas patterns generated using both the flexible pear rod and the flagrum replica (Figures 21, 22, 23) better match the TS scourge marks.



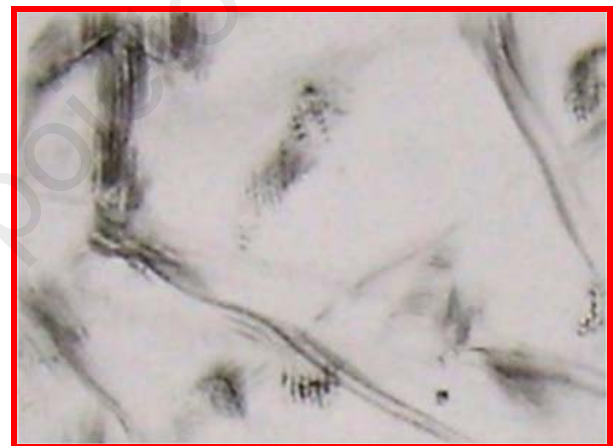
**Figure 19.** Experimental marks obtained using a flagrum replica.



**Figure 21.** Experimental marks obtained using both a flexible pear rod and a flagrum replica.



**Figure 20.** Detail of experimental marks obtained using only the flagrum replica.



**Figure 22.** Detail of experimental marks obtained using both a flexible pear rod and a flagrum replica.

## 5. CONCLUSION

New image processing of the TS confirms the presence of 3 different kinds of scourge marks, related to the use of at least 2 different kinds of whips on the TS and much more faint; they look like a fan composed by 3 - 4 thin curved stripes.

Type 1 marks are characterized by two or three spheres (about 0.8 mm in diameter) connected by small bars, and are compatible with the signs left by a *Roman Flagrum*. Type 2 marks show relatively large and striate bands of variable length, similar to scratches and are compatible with flexible rods, like the famous "*Virgae*" used both as torture instrument and as power symbol by the lictors.

Type 3 marks are more rare (they occur less than 15 times).

Experiments simulating scourging gave imprints similar to those of the TS if both whips, the flexible rods and the



**Figure 23.** In analogy with Fig. 13, where Type 2 scourge marks are overlapped to the image of Fig.11, flexible pear rod patterns are evidenced with respect to the patterns let by the flagrum replica, to show the similarity of the experimental results with the TS.

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flagrum, are used.

Type 1 and Type 2 marks frequently cross each other and are overlapped by other blood marks, like the so called "blood belt" and the outflows from the wrists, indicating that they preceded other tortures in the temporal sequence of the execution of the TS Man.

Type1 marks randomly overlaps Type2, leading to the conclusion that the TS Man was whipped with the Roman Flagrum, after being beaten with flexible rods.

In the hypothesis that the TS Man is Jesus of Nazareth dressed with a tunic which protected him from the next lashes, and knowing that Type 3 marks can be only found on the TS legs (probably not covered by the tunic), we can suppose that Type 3 marks are the result of the whipping of the TS Man during his uphill to the Calvary.

The number of flagrum lashes counted by the first author on the TS is 196; the minimum number of bloodstains produced by both kinds of scourging counted by the second author on the TS is 372 (159 on the front image and 213 on the back image).

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