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# Treatment Outcome and Prognosis Regarding to MR Pattern and Signal Area in Spinal Cord Injury

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– Abstract –

**Study design**: To determine the capability to predict the clinical manifestations and treatment outcomes of traumatic cervicothoracic cord injury patients  based  on MR images.

**Objective**: To determine the relationship between the differences in MR patterns and signal areas according to Maravilla and Cohen's classification and the PACS system compared with the Frankel classification, in patients that demonstrated neurologic improvement within 1 year.

**Summary of Literature Review**: MR is the first imaging modality that directly visualizes the extent of spinal cord derangement, and thus, it has the potential  to provide an accurate diagnosis of an injury   and to determine  the prognosis.

**Materials and Methods**: MR images were evaluated within 3 days  of trauma in 36 spinal cord injury patients. The clinical follow- up period was more than 1 year. Quantitative analysis of spinal cord lesions was performed  according to the PACS system.

**Results**: According to Maravilla and Cohen's classification, 36 cases were classified as follows: 8 cases of type I, 10 cases of type II, 9 cases of type III and 9 cases of type IV. There was 1 case of type I, 8 cases of type II, 5 cases of type III, and no cases of type IV, who demonstrated neurologic improvements of more than 1 grade in the Frankel classification. An analysis of the signal areas according to the PACS system demonstrated no cases of areas greater than 100 mm$^2$, 5 cases of areas between 50 to 100 mm$^2$, and 9 cases of areas less than 50 mm$^2$ who demonstrated neurologic improvement.

**Conclusion**: Classification according to the differences between MR imaging and MRI signal areas in patients with spinal cord injuries demonstrated the indicators of neurologic improvement;  therefore, we MR imaging can be utilized as a prognostic factor in cases of spinal cord injuries.

**Key Words**: Spinal cord injury, MRI, PACS system

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*              2005                                                      .

1998   12      2004   6

3

1                                    36

GE      signa

EXCITE HD 1.5T    MRI           .

(CT)                  22      ,        14                    20

1)                 5   , 30     12   , 40      11   , 50            8

30, 40

(Table 2).

20   ,        16       .

15   ,          11

Allen                                  9

,              3   ,              2   ,

1        (Table 3),                  McAfee

5   ,            3   ,

2   ,              1          (Table 4).

**Table 1**. MR Pattern of Spinal Cord Injury Following Acute Trauma

| Type | T1 signal | T2 signal | MR imaging course | Probable pathology |
|------|-----------|-----------|-------------------|--------------------|
| I | Inhomogeneous | Central Peripheral | Resolution over weeks | Frank hemorrhage |
| II | Isointense to cord | Central Peripheral | Resolves rapidly | Edema |
| III | Isointense to cord | Central: isosignal Peripheral | Partial resolution 7-10 days | Contusion/petechial hemorrhage |
| IV | Transection | Transection | Late retraction: scarring | Transection |

**Table 2**. Age Distribution

| Age | Case |
|-----|------|
| < 30 | 5 |
| 30~ 40 | 12 |
| 40~ 50 | 11 |
| > 50 | 8 |

**Table 3**. C-spine Injury

| Allen classification | Case |
|----------------------|------|
| Distractive flexion | 9 |
| Compressive flexion | 3 |
| Distractive extension | 2 |
| Vertical compression | 1 |
| Total | 15 |

,

.

(mehtyl .

prednisolone) 30 mg/kg 15 ,

23 5.4 mg/kg . 3 .

, .

. Spinal shock , ,

, , , , ,

. 1 Frankel [2](Table 5) 1
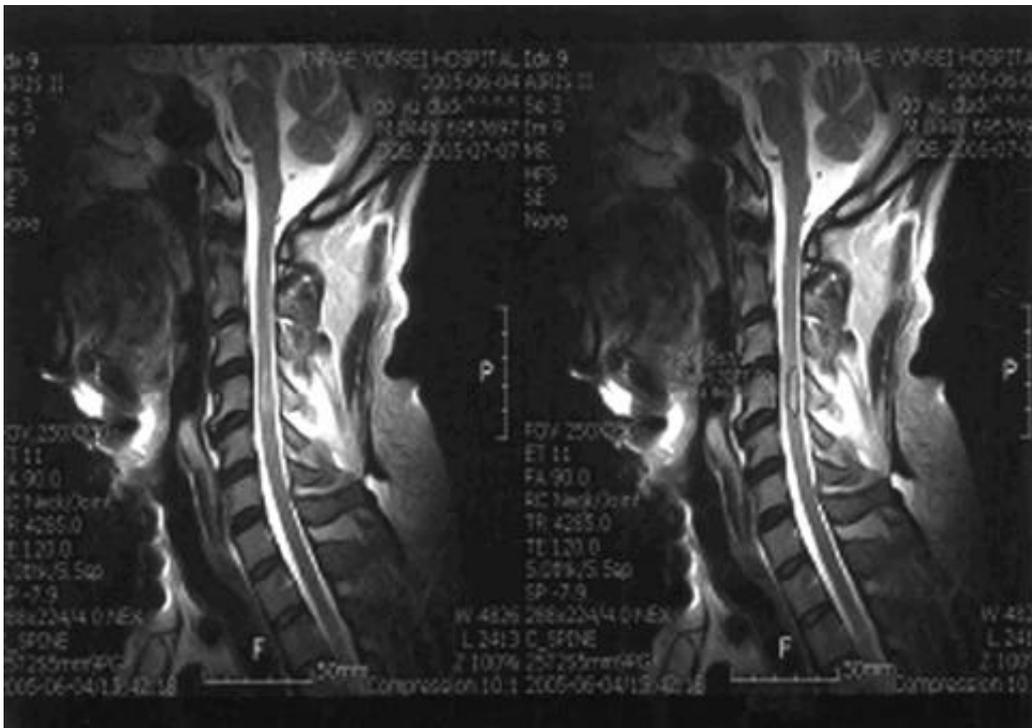


**Fig. 1.** Quantitative analysis of signal changes on MRI(PACS system). (SD: standard deviation, mean, area : mm²)

**Table 4**. T-spine Injury

| McAfee classificaton | Case |
| --- | --- |
| Unstable burst fractures | 5 |
| Chance fractures | 3 |
| Flexion distraction injuries | 2 |
| Translational injuries | 1 |
| Total | 11 |

**Table 5**. Frankel Classification System

| | |
| --- | --- |
| A. Complete | |
| B. Incomplete | Preserved sensation only, ie, voluntary motor function absent |
| C. Incomplete | Preserved motor (nonfunctional), ie, motor function that performs no useful purpose |
| D. Incomplete | Preserved motor (functional), ie, motor function useful |
| E. Complete recovery | May have abnormal reflex |

PACS system(Maroview)

³⁾.(Fig. 1)

Maravilla    Cohen  ¹¹⁾

(Table 1).                           ROI(Region of
Interest)              SD(standard deviation), mean,
area                 ,                  Frankel
(chi-
square test)                              .

1       ,      1        ,       1
1
Frankel      ²⁾  1
Mar-
avilla    Cohen⁴⁾              1
8        Frankel     A    6   , B    2
1  (12%)
,   2                  11
A   3     2  , B   3     3  , C   2     1  , D   2
2                        E
1                    11      8  (72%)
,    3
9        B    4    2  , C    5    3  ,    5
(55%)                          .   4
8          A      A
(Table 6).              2  , 3
1  , 4
(p<0.05).
PACS                     (area)
100 mm²                                   8  ,
50~100 mm²                 19  , 50 mm²
9      ,    36

**Table 6**. MR Patterns of Cord Injury and Neurologic Recovery

| Type | Recovery |
|------|----------|
| I    | 1/8 (12%) |
| II   | 8/11 (72%) |
| III  | 5/9 (55%) |
| IV   | 0/8 (0%) |

14        , PACS
100 mm²                       , 50~100 mm²
5   (26%), 50 mm²          9   (100%)   . 50~100
mm²                          19
50~60 mm²         3  , 60~70 mm²         3  , 70~80
mm²         5  , 80~90 mm²       3  , 90~100 mm²
5      ,                              50-
60 mm²        2  (67%), 60~70mm²        1  (33%),
70~80 mm²       2  (40%)   ,             80 mm²
(Fig.
2)(Table 7).

PACS
50 mm²

,                 100 mm²

.         MRI
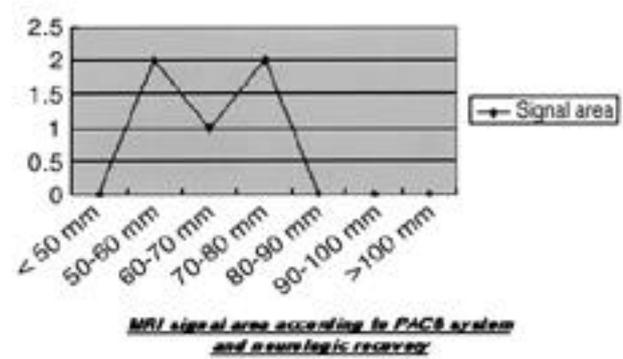


**Fig. 2.** MR signal area according to PACS system and Neuro-
logic Recovery
: Analysis of the signal area according to the PACS sys-
tem, there were no case of area above 80mm² who
showed neurologic improvement.

**Table 7**. MR signal area according to PACS system and Neu-
rologic Recovery

| MRI signal area (PACS) | Recovery |
|------------------------|----------|
| >100 mm | 0/8 (0%) |
| 50-100 mm | 5/19 (26%) |
| <50 mm | 9/9 (100%) |
| 50-60 mm | 2/3 (67%) |
| 60-70 mm | 1/3 (33%) |
| 70-80 mm | 2/5 (40%) |
| 80-90 mm | 0/3 (0%) |
| 90-100 mm | 0/5 (0%) |

,                    80 mm$^2$                                                                        .

1                    . ,  MRI                Kulkarni [15]                                                        1                (          72

50 mm$^2$

, 80 mm$^2$                                                                                  )          T1

,                                                                                  ,

. (p<0.05)                                                                        T2

(          3          7          )

,

. 2          T1

,                    T2

,                    ,                                                                                                            . 3

,                    CT,          T1                                                                        ,

,                              .                                        T2

1

,

.                                              .

.

Maravilla    Cohen[4]

Schaefer [5]                                                                        4                                        ,    I

T1                                                        T2

,          ,

,    II        T1

T2

,                                        6),7),8),9),10),11),12),13),14)

(Fig. 3),        III        T1
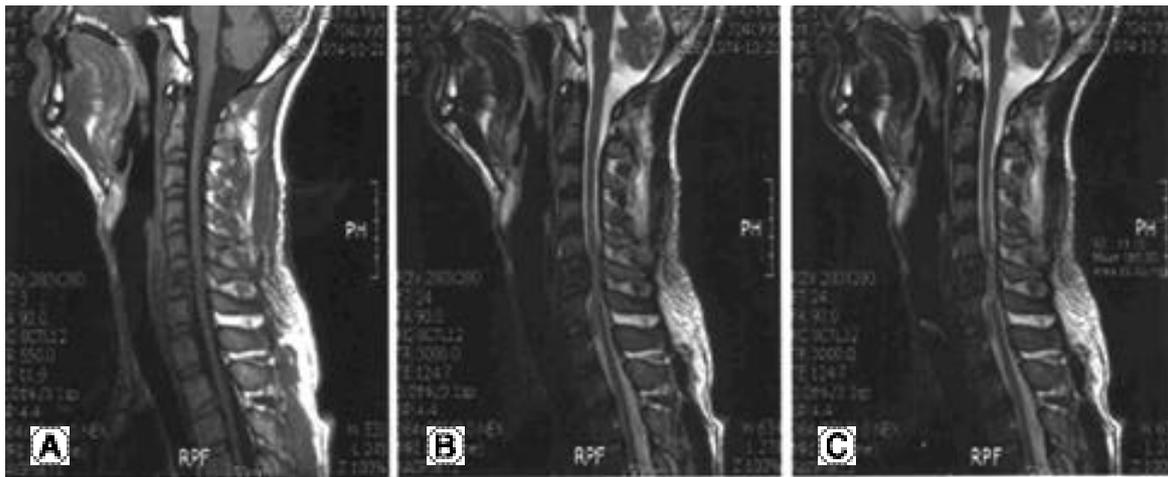


**Fig. 3.** (Type II) MRI of 22-year-old male with C6 tear-drop fracture who become incomplete quadriplegia following incar-TA. Shows neurologic recovery(Frankel grade C to D).
(**A**) T1 isointense (**B**) Central isosignal, peripheral high (**C**) Signal range : 62.81mm$^2$

T2                                                          .

PACS system

(Fig. 4),

IV                                    (Fig. 5).

I        8        , II        10   ,

III      9   , IV      9                  ,    2  , 3                                        Maravilla & Cohen              I,

1   , 4                                    IV

.    Maravilla    Cohen   [4]                                                                      .

I                                        Kulkarni   [15]

, II                                    , III

7~10                                          , IV

Kulkarni   [15]
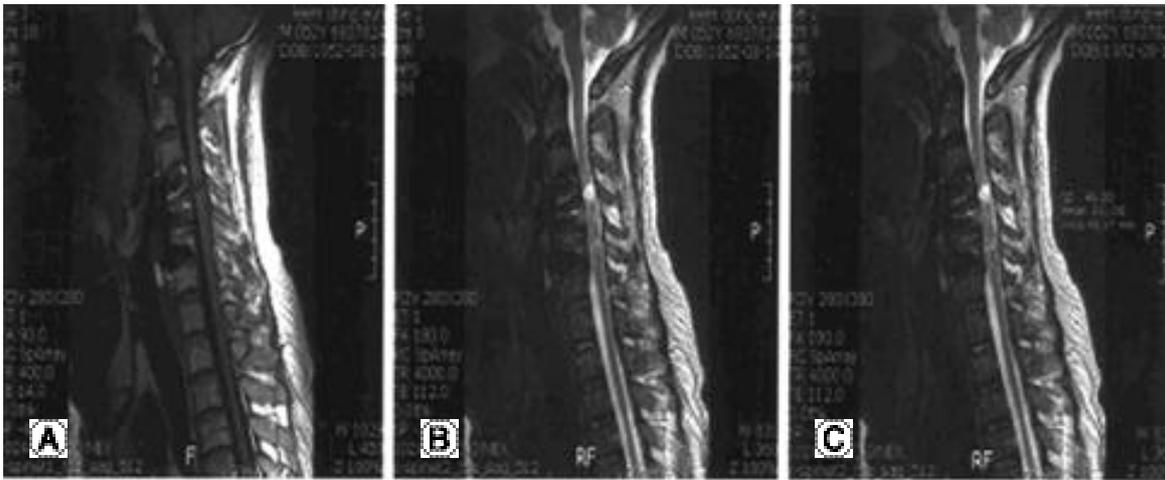


**Fig. 4.** (Type III) MRI of 50-year-old male with C5-6 fracture and left unilaterl facet joint dislocation who become incomplete quad-
riplegia following fall down accident. Shows neurologic recovery(Frankel grade B to D).
(**A**) T1: isointense  (**B**) T2: cetral high, peripheral high , C5 level Syringohydromyelia, intramedullary, C4 level (**C**) Signal
range : 40.67mm$^2$



**Fig. 5.** (Type IV) MRI of 48-year-old male with T11-12 fracture and dislocation who become complete paraplegia following outcar-
TA. Not shows neurologic recovery(Frankel grade A to A).
(**A**) T1: transection (**B**) T2: transection (**C**) Signal range : >100mm$^2$

Maravilla    Cohen[4]                                    . Hackney
[10)]                                 T1                                                    ,
           T2                                                                          .
                  , Osterholm[16)]
                                                      ,                              .
                  ,         ,
                                                                        10          26
      . Gomori      [17)]
            T2                                                                          .




                                    .

                              ,         ,

      ,         ,         ,
            ,                              CT
                                                      MRI
      Koyanagi      [18)]                                                              ,
                  .                        PACS system                              80
                                          mm$^2$
                                                                              .

                              .

                                                                              ,
                                                                        .



                  ,

[19)].

                              ,
      CT                        .
            (spinal shock)
                        ,
            ,
      .
                        .
                  .
            .
                  .                        ,
      ,

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Maravilla Cohen PACS system 1 Frankel classification

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1 36 . PACS system

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: Maravilla Cohen I 8 , II 10 , III 9 , IV 9 1

Frankel 1 I 1 , II 8 , III 5 , IV

. PACS (area) 100 mm² , 50~100 mm²

5 , 50 mm² 9 .

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: , , PACS

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3 1

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