Development of the Robo Cylinder impactor for spinal cord injury model

Jeong-Kyu Yang' , Chul-ung Kang[2] and Ki-Bum Sim[i]

Authors of 1,2 are in Department of Mechartronics Engineering,
Author of 3 is School of Medicine
JEJU national University, Korea
yjkanvo@empas.com; cukang,kibumsim@jejunu.co.kr

Abstract. In this paper, we developed the Robo Cylinder Impactor(RCI) using motion controller and power cylinder. RCI is the device for spinal cord injury model which can impact exact impulse to spinal cord so that it will have high reproducibility compare with previous impact devices. It can be incarnated the Contusion, Compression impact system(;used the previous spinal cord injury model)in one device. RCI can be anticipated the damage of the spinal cord because it can be checked as a numerical data connected impulse to the spinal cord. Through the impact test using RCI, we propose the possibility that RCI can be applied to spinal cord injury model.

Keywords: Spinal cord injury; SCI device; Robo cylinder impact device;

1 Introduction

It is necessary for laboratory animal model with similar to study the human's spinal cord injury. Impact device for animal's spinal cord injury model should be considered dynamic, histopathological and functional results[1][2]. Mostly, human's spinal cord injury is caused by excessive compression or contusion. Until today many researchers has been using the animal's spinal cord injury model. The most common way is weight drop contusion model and compression model[3]. The weigh drop contusion and the clip compression models played an important role in the discovery of progressive secondary tissue damage[4]. However, commonly used contusion models have low reproducibility and compression models are shown too severe injuries[5]. So, we was developed the Robo Cylinder Impactor system for compensating the defect of animal's spinal cord injury model. RCI was developed with using Motion controller and Power Cylinder. This system have high reproducibility due to control spinal cord's transform depth, dwell time and precise impulse. Also, contusion model and compression model can be used in one device so it is possible to print a data points. Therefore, using numerical data followed by each experiment that can analyze impulse and transform depth in order to anticipate the scale of lesion. In this study, we have developed RCI device that can adopt animal's spinal cord injury model through general impact experiment.

2 RCI system configuration

Motion controller can be moved on X,Y,Z coordinate it will give the freedom to move the target position precisely. Power cylinder is fixed z coordinate of motion controller then give an impact by exercise stroke with impact tip. It is operated by produced program in main controller and variables such as force, speed, location, can be changed freely. At first, the experimental image using the camera become calibrated by the program of main controller and then the value of calculated real distance transmit to the main controller. Motion Controller makes impact tip to reach the target position. The height of the target position can be calculated by power cylinder's Soft-Land program. It can be connected the impact that depend on the variable set in program after reaching the target point.

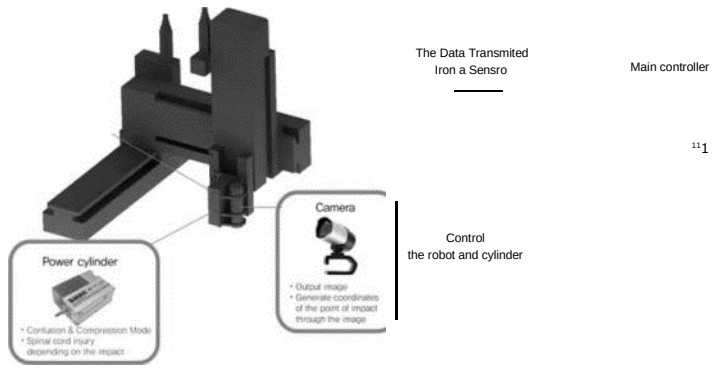

Fig. 1.RCI system configuration

3 Injury target positioning method

3.1 Height

To control Z coordinate of motion controller, it is necessary to grasp the distance between the target position and impact tip. We applied Soft-Land program to cylinder register for calculate the height. Soft-Land program is going down with the force it cannot give an impact on the target. Once it sense the repulsive force, then lift the stroke so that can be figured out location value of reach moment.

3.2 Target position

Using Main controller's image need to anticipate the distance which is considered feature of camera in order to create X and Y coordinate. Figure [2] shows the shape of the section in camera.

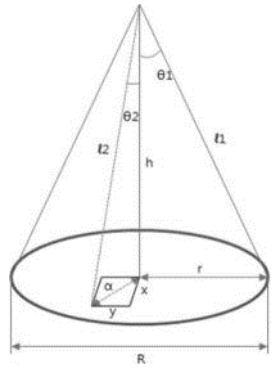

Fig. 2.Distance prediction model for image

R is real distance of plane and h is the distance to target position. If the angle of view by half(;with camera's feature) is 0_1.

$$8_1 = \text{COS}^{-1}\frac{h}{} \quad (1)$$

Target position's coordinate are X and Y which is shown in Fig [2], straight line distance from starting point to target position is a and then 0_2 is calculated by proportional expression about pixel amounts.

$$^{0}2 = \frac{\text{COS } h}{r \qquad 1_1} \quad (2)$$

Therefore the real distance is tan 0 ^{2}from the a point.

$$a = \frac{\tan ey}{h} \quad (^{3})$$

Despite the same pixel points of shown image, real distance is shifted according to height value h and it move to created coordinate with calculation.

4 Impact model

4.1 Contusion model

In contusion model, the momentum is changed by dint of impactor's mass and velocity of stroke. It is extremely moment that impact tip reach the target position and sustained. If the impactor's mass is fixed, momentum can be differed by change of velocity.

$$\mathbf{P=m\ x\ v} \quad \mathbf{(4)}$$

RCI is tied up torque of Power cylinder then conduct experiment by changing speed and calculate speed with encoder's value. The delivered momentum is calculated using set weight and speed relationship equation.

4.2 Compression model

The impulse is integral value according to the connected force and variable of time in compression model. Therefore if the dwell time is different impulse can be changed.

$$DP = \mathbf{F\ x} = \mathbf{f\ F\ x\ dt} \qquad (^{5})$$

In RCI device, fixed speed of Power cylinder and change. The time duration of the impact tip to reach target position was monitored. Force is impactor's weight add up cylinder's torque so write changing sustain time to find out impulse.

5 Experimental method

We progressed the impact test with contusion mode and compression mode. Data is collected each 10ms and analyzed with Matlab program. In contusion experiment, sustain the weight of impactor to 40g and change speed to 50mm/s and 100mm/s. In compression experiment, we progressed the test that the delay time is 30s, 50s with maintained mass of impactor. Both contusion and compression tests are done on wet sponge. The impactor used in the experiments are 2mm diameter steel with round impactor tip. The same impactor was used throughout the experiments.

6 The result of an experiment

The Fig [3] shows the result of contusion mode. The target position is located 1 Omm away from zero point and this state is regardless of inertia. No sooner both result take about within 50ms than it is shown to reach a target speed. It takes about 0.1-0.2s to reach the sponge according to the speed, and the impactor returns to the origin. It seems that the impact was passed by the relationship between the impactor mass and stroke velocity.

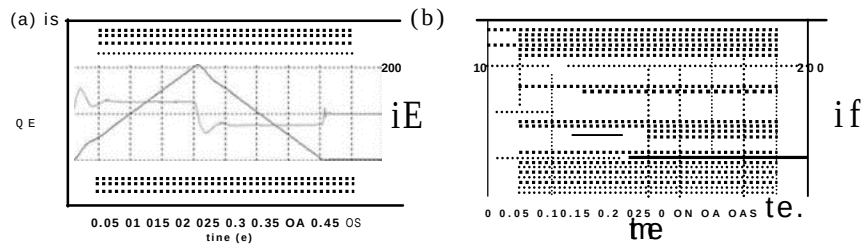

Fig. 3.Contusion mode graph 50mm/s(a) and 100mm/s(b)

The Fig [4] shows the result of compression mode. It similar like the contusion mode, it reach on the target position(10mm) through the acceleration. The time to return from starting point after impact tip reach at the 10mm point is called dwell time. Therefore, we can be calculated a value of the impulse according to control the dwell time and measuring the torque of cylinder. The velocity of impact tip is 2mmis and it reach the target point within 5s. The dwell time is 30s and 50s, respectively. The result of this experiment correspond with the target time.

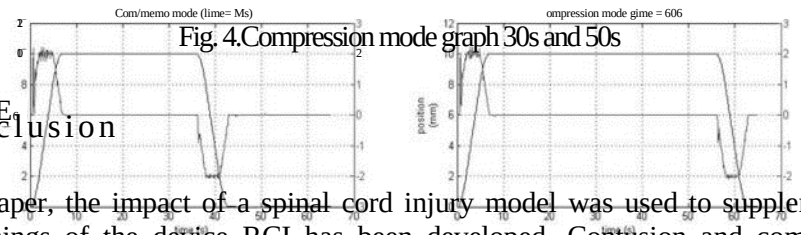

Fig. 4.Compression mode graph 30s and 50s

7 Conclusion

In this paper, the impact of a spinal cord injury model was used to supplement the shortcomings of the device RCI has been developed. Contusion and compression mode is shown almost same result set up a data before the experiment. Also, RCI can be changed freely variable(;force, velocity, location). The result of an experiment, RCI can be expected to apply to the spinal cord injury model because it is shown exactly the result according to set a variable. RCI is produced that Contusion and Compression mode can be executed in one device, we are expected to develop with loadcell and laser sensor additionally. We seems to have judged that it can be used to develop the spinal cord injury model after a few upgrades. We are expecting this model will be useful to treat various spinal cord injuries in the near future.

References

1. Seok-Min Choi, Jong-Sik Suk, Jeoung-Taik Kwon, Byung-Kook Min, Sung-Nam Hwang, Young-Baeg Kim, Duck-Young Choi, Jae-Hyun Kim, Development of Ugraded Cortical Impact Model(Part I : Mechanics). 2002, J. Korean Neurosurg Soc 32: 29-34
2. Seok-Min Choi, Jong-Sik Suk, Byung-Kook Min, Sung-Nam Hwang, Young-Baeg Kim, Jae-Hyun Kim, Development of Ugraded Cortical Impact Model(Part II : Functional outcome). 2002, J. Korean Neurosurg Soc 32: 458-462
3. Sang-Jun Yeo, Sung-Nam Hwang, Seung-Won Park, Young-Baeg Kim, Byung-Kook Min, Jeong-Taik Kwon, Jong-Sik Suk, Development of a Rat Model Graded Contusive Spinal Cord Injury Using a Pneumatic Impact Device. 2004, J. Korean Med Sci 19: 574-580
4. W. Young, Spinal cord injury, 2002 Elsevier Science Chapter 17:231-243
5. Do-Hyun Kim, Seung-Dam Heo, Ki-Bum Sim, Tae-Kyun Shin, A model of acute severe spinal cord injury in rats using a vascular clip. 2003, J. Subtropical Agri. & Biotech. 19(1):63-70