AMJ Australasian Medical Journal [AMJ 2020;13(12):310-316]

Effect of a double dose of photobiomodulation therapy on orthodontic pain caused by elastomeric separators

Marina Simunovic Anicic[1], Vjera Perkovic[2], Dragana Gabric[3], Vlatka Lajnert[4], and Senka Mestrovic[5]

1. School of Dental Medicine, University of Zagreb, Zagreb Croatia
2. Department of Orthodontics, Faculty of Dental medicine, University of Rijeka, 51000 Rijeka, Croatia
3. Department of Oral Surgery, School of Dental Medicine, University of Zagreb, Zagreb Croatia
4. Department of Prosthodontics, Faculty of Dental medicine, University of Rijeka, 51000 Rijeka, Croatia
5. Department of Orthodontics, School of Dental Medicine, University of Zagreb, Zagreb Croatia

RESEARCH

Please cite this paper as: Simunovic Anicic M, Perkovic V, Gabric D, Lajnert V, Mestrovic S. Effect of a double dose of photobimodulation therapy on orthodontic pain caused by elastomeric separators. AMJ 2020;13(12):310–316. https://doi.org/10.35841/1836-1935.13.12.310-316

Corresponding Author:
Marina Simunovic Anicic
Gunduliceva 5, 10000 Zagreb, Croatia
Email: simunovicst@gmail.com

Background
It has been reported that 90 per cent of patients experience pain during orthodontic treatment. Laser photobiomodulation (PBM) is the application of light to pathology to encourage tissue regeneration, decrease inflammation and is wieldy used for pain relief.

Aims
The purpose of this study was to evaluate the efficiency of PBM in decreasing pain caused by elastomeric separators at the beginning of the orthodontic treatment.

Methods
Twenty-two patients were recruited to participate in this single-blinded, placebo-controlled study. Four elastomeric separators were placed mesially and distally to the upper first molar on each side. The right side of the upper jaw was treated with a low-power diode laser, and the left side was given a placebo (the same treatment with the laser switched off). Two doses of PBM therapy (660nm, 90mW) were delivered 24 hours apart. The participants filled out a questionnaire immediately after the placement of the separators, before the 1st laser treatment (TO) and 12 hours (T1), 24 hours (T2), two days (T3) and three days after the 1st treatment (T4). At each evaluation period, the degree of pain was scored twice, once for each side.

Results
Both sides perceived greater pain at 12 hours and maximum pain at 24 hours. Pain decreased on day 3 on both sides. A significant reduction in pain (p=0.01) was detected at 24 hours on the laser-treated side compared to the placebo side. No other significant difference between sides was observed.

Conclusion
Based on this study, we can conclude that PBM therapy significantly reduces pain 24 hours after separator placement, when the pain is at its peak. However, it does not affect the pain at other time intervals. These findings suggest promising effectiveness of PBM therapy.

Key Words
Orthodontics, pain, photobimodulation, diode laser, low-level laser therapy

What this study adds:

1. What is known about this subject?
Past studies in this field have yielded contradictory results concerning the outcomes of PBM therapy on relieving pain after the insertion of orthodontic separators.

2. What new information is offered in this study?
PBM therapy has effect 24 hours after the insertion of orthodontic separators when the pain is on the highest level. A double dose of irradiation has no additional effect on pain reduction

3. What are the implications for research, policy, or practice?

Further researches in this field are necessary to determine optimal laser dose in treating orthodontic pain.

Background

Placing elastomeric separators is a part of the orthodontic treatment to create space for orthodontic bands. This initial tooth displacement induces pain and instant release of biochemical mediators, such as prostaglandin-E2, substance P and interleukin 1-beta.[1]

It has been reported that 90 per cent of patients experience pain during at least one part of orthodontic treatment.[2] The pain starts two hours after the application of an orthodontic fixed appliance, increases over the next 24–36 hours, starts to decrease on day 3 and disappears within 6–7 days.[3] The feeling of pain is a subjective response that depends on various factors, such as age, gender, stress, present emotional state, cultural differences, previous pain experiences and the magnitude of applied force .[4]

There are two principal groups of methods for controlling orthodontic pain: pharmacological and non-pharmacological. Non-steroidal anti-inflammatory drugs are the gold standard for pain control; however, the use of these drugs can be associated with side effects, such as gastrointestinal intolerance, thrombocytopenia, skin rashes, renal insufficiency and headaches.[5] It has also been reported that nonsteroidal anti-inflammatory drugs can affect tooth movement.[6]

Laser photobiomodulation (PBM), also called low-level laser therapy (LLLT), is the application of light to a pathology to encourage tissue regeneration, decrease inflammation and relieve pain.[7] The wavelengths used for this purpose are in the red and infrared spectrums (600–1,000nm). There is no complete understanding of the mechanisms behind PBM; however, there has been an enormous growth of research in this area. PBM has an impact at the molecular, cellular and tissue levels.[8] At the cellular level, the changes that occur are in the metabolism of the cell. Once the light from the PBM is applied and the photon enters the cell, it is absorbed mainly by the mitochondria, specifically by cytochrome c oxidase.[9] This leads to changes in the membrane potential of the mitochondrion and in turn to the greater synthesis of ATP, leading to greater expression of growth factors and increased cell proliferation, among many other events.[10] Immune cells are greatly affected by PBM, which promotes wound healing.[8]

Several advantages of PBM therapy have been proposed in the literature from the beginning to the end of therapy, including the reduction of pain after separators have been placed[11-14] and afterwards during the treatment,[15,16] the acceleration of tooth movement,[17,18] tissue regeneration after rapid maxillary expansion,[19] eased debonding of ceramic brackets[20,21] and eased resin removal after debonding.[22]

Past studies in this field have yielded contradictory results concerning the outcomes of PBM therapy on relieving pain after the insertion of orthodontic separators. Some studies have shown a positive effect[16,23-26] in pain reduction, and some have shown no effect.[11,18,27] The studies with positive outcomes have no consistent specifications for wavelength, dose, radiant exposure, irradiance, tip diameter, average power output, peak power (for gated mode), time or position of the points of application.[28]

Thus, the purpose of this study was to evaluate the efficiency of low-level diode laser treatment in decreasing pain caused by elastomeric separators at the beginning of an orthodontic treatment. The null hypothesis for this study was that no difference existed between laser-treated and placebo-treated sides in terms of the pain caused by elastomeric separators.

Method

Study design

This is a single-blinded, placebo-controlled split-mouth study. The design of this study was split mouth to eliminate all factors related to differences among subjects. The study was carried out at the Department of Orthodontics within the University Dental Clinic at the Clinical Hospital Center of Rijeka. Ethical approval was obtained from the Ethical Committee of the Clinical Hospital Center of Rijeka, Croatia (003-05/2/-1-/22, 2170-29-02/1-20-2).

Sample size

The sample size was decided via power analysis (G*power 3.1.) based on the results of a previous study[29] and predicting a study power of 0.95 and a significance level of 0.05. The program calculated a required sample size of at least 22 participants.

Participants and inclusion criteria

The sample included 22 participants (12 females and 10 males, mean age: 15.1 years) (Table 1).

Table 1: Sample characteristics

Variable
Gender
Male 10 Female 12
Age (years)
Mean (SD) 15.1 (1.8) Range 11.8-19.9

All the participants provided informed consent. For minor participants, informed consent was obtained from the parents.

The inclusion criteria for participants were as follows: patient age between 12 and 19 years, no previous orthodontic treatment, good general health, permanent dentition (including erupted second molars), intact first maxillary molars, good interproximal contacts on all first permanent molars and healthy periodontal tissues (gingival index=0, plaque index<1, probing depths<3mm, no periodontal attachment loss and no radiographic evidence of periodontal bone loss). The exclusion criteria were as follows: gingivitis or periodontitis, interproximal fillings, missing teeth, crowding or spacing in the premolar and/or molar area, severe systemic disease and antibiotics and/or analgesics prescribed during the study period or 15 days prior.

Anamnestic questionnaires were handed out to participants, their panoramic radiographs were examined and a detailed examination of the oral cavity was performed.

The same investigator enrolled all the subjects. Figure 1 shows the number of patients who were eligible for the study and who were enrolled. Patients who took any kind of medicine that could have changed their perception of pain were excluded from the study.

Procedure

Four elastomeric separators (American Orthodontics, Sheboygan, WI, USA) were placed mesially and distally to the upper first molar on each side with a specially designed plier (Hu-Friedy, Chicago, IL, USA).

Both the laser and the placebo treatments were applied using a diode laser (Laser HF, Hager-Werken GmbH & Co., Duisburg, Germany), which was set on PDT mode (660nm) and acupuncture mode. The power of the laser was set at 90mW in intervals of 80 seconds, as recommended by the manufacturer. It was determined in advance that the right side of the upper jaw would be treated with a laser, and the left side would be administered a placebo.

The laser was applied perpendicularly in contact with the mucosa on one point of the buccal and one point on the palatal side of the first molar approximately on the middle part of the root, with a 10mm distance from the laser to the mucosa. Each point was treated in three intervals of 80 seconds each for a total of total 240 seconds on the vestibular and 240 seconds on the palatal side per tooth. The treated surface was $1cm^2$. The power of the laser was 90mW, wavelength 660n, beam area $1cm^2$, irradiance per target $0.09W/cm^2$, and during the 240 seconds of treatment, $21.6J/cm^2$ of energy was delivered per point, with a total energy of 43.2J per tooth applied. The placebo side was treated in the same way with the laser switched off but with the sound signal maintained, which implied that the laser was working so that participants were blinded to the allocation of the group; only the operator knew whether each side was laser or placebo treated. During the period of the laser irradiation, both the patient and the orthodontist used goggles designed to block the laser's wavelength.

The same laser treatment was performed the next day because the pain was noted to be greatest within 24 hours after the placement of separators.

Pain assessment

The pain was assessed with a visual analogue scale (VAS), which is a 100-mm-long horizontal line of which one end corresponds to "no pain" and the other end indicates "the worst pain possible."

The participants filled out the questionnaire immediately after the placement of the separators (TO), before the 1st laser treatment, 12 hours (T1), 24 hours (T2) and just after the 2nd laser treatment, and 2 days (T3) and three days after the 1st treatment (T4) (Table 2). At each evaluation period, the degree of pain was scored twice, one for each side. Each patient was required to indicate whether he or she had taken any analgesics during the recorded period.

Table 2: Timeline

Day 0	Day 1	Day 2	Day 3
Sep placed	LASER 2	VAS T3	VAS T4
VAS T0	VAS T2		
LASER 1			
VAS T1			

Statistical analysis

Microsoft Excel Software was used for data collection. The data were statistically analysed using SPSS program version 20 (GraphPad Prism version 8.00 for Mac, GraphPad Software, La Jolla California, USA). According to the Shapiro–Wilk test, the data were normally distributed. The t-tests were used to compare the differences between gender and age groups. The paired t-test was used to compare the mean pain scores between the experimental sides and the placebo sides. Significance was set at $p \leq 0.05$.

Results

Both sides perceived greater pain at 12 hours and maximum pain at 24 hours. Pain decreased on day 3 on both sides. The paired t-test showed a significant reduction in pain (p=0.01) score at 24 hours on the laser-treated sides. No other significant differences between sides was observed (Table 3).

Discussion

In this clinical study, we evaluated the effects of a double dose of LLLT on the pain associated with tooth movement (placement of orthodontic separators). Temporary placement of elastomeric separators has been used in many studies to stimulate pain at the beginning of orthodontic treatment.[14,25,26,29]

Pain is a highly subjective experience; thus, we decided to use a split-mouth design, which enables within-subject control. This method is very appropriate for the study of pain because it nullifies the effects of inter-individual variations in the perception of pain.[30] This design has been used in various pain-related studies.[24,27,29,30]

The small sample size, the result of many dropouts during the study, can be considered a shortcoming of this study.

VAS score is a widely used method for pain measurement[3,27,29] and has been found to be reliable.[31] The present study used VAS to try to detect changes in the level of pain overtime after a double dose of diode laser treatment compared with a placebo.

Pain levels in this study were recorded for four days (separator placement at day 0 and on the 1st, 2nd and 3rd days after placement). There were no differences in the average onset of pain between the experimental and placebo groups. The most painful day was the same in both groups (1st day). Prior studies have shown that pain reaches a maximum level in 24 hours, decreasing on the 3rd day after separator placement or orthodontic activation.[3,5,14,32] These past results are consistent with those of the present study: Higher values for pain were detected after 12 hours, pain peaked at 24 hours, and after 48 hours, the pain started decreasing and had decreased considerably 72 hours after separator placement.

The recent meta-analysis[33] demonstrated that analgesics and LLLT therapy are the most effective interventions for managing orthodontic pain. The laser chosen for this study was a diode laser set at acupuncture mode with a wavelength of 660nm and a power of 90mW, with 21.6J/cm^2 of energy per point. No earlier studies were found to use a laser with the same wavelength and dose. Turhani et al.[16] used a single-dose continuous laser (670nm and 75mW) after fixed appliance placement and showed that laser irradiation reduced pain after six and 30 hours. Other studies used different wavelengths and doses. Kim et al.[25] showed a significant reduction in pain 24 hours after separator placement when laser-treated (630nm, 6mW) cases were compared to a placebo group and the control group and these results are in accordance with those of the present study. Artes-Ribas[24] (830nm, 100mW) et al. noted significantly lower pain intensity in the laser-treated than in the placebo-treated side. Abtahi et al.[26] found a significant difference in pain reduction in the experimental side after five doses of LLLT (830n, 100mW) compared to the control side on the 2nd day only, which coincides with our results. Other reports demonstrated significant pain reduction between the PBM-treated side and the placebo/control side at all time intervals over seven days (940nm, 200mW),[29] at six different time intervals (910nm, 160mW)[13] and in the first four days.[34] The meta-analysis from 2015 concludes that PBM therapy can reduce pain at 6 hours and on the 1st, 2nd and 3rd days after the placement of the separators,[35] which is partially in alignment with our results To the contrary to the results obtained in this study, the results from two studies[11,27] demonstrated no significant reduction in pain perception after PBM therapy as well as the results of a recent study in which they investigated two energy values of PBM therapy and demonstrated no effect in reducing pain induced by elastomeric separators.[18] In the present study, PBM therapy yielded a significant reduction in pain the 1st day after the separator placement.

The double dose of irradiation was chosen to obtain an accumulative effect; however, on the 2nd day, VAS scores showed no significant reduction in pain. This is in accordance with a recent study[36] in which the researchers compared the effects of single- and double-dose irradiation (830nm, 100mW) and concluded that double-dose irradiation has no additional impact in pain reduction. On

the contrary, the results from another study[37] (810nm, 100mW) employing a double dose of laser irradiation demonstrated a significant reduction in pain in the first three days.

Conclusion

Based on our research, we can conclude that PBM therapy significantly reduced pain 24 hours after separator placement, when the pain was at its peak; however, it had no effect on the pain at other time intervals. A double dose of irradiation had no additional effect on pain reduction. These findings suggest that PBM therapy has encouraging effects. Nevertheless, further research is needed to determine the best protocol for PBM therapy that could deliver more optimal results in pain reduction during orthodontic treatment.

References

1. Giannopoulou C, Dudic A, Kiliaridis S. Pain discomfort and crevicular fluid changes induced by orthodontic elastic separators in children. J Pain. 2006;7(5):367–76.
2. Lew KK. Attitudes and perceptions of adults towards orthodontic treatment in an Asian community. Community Dent Oral Epidemiol. 1993;(21):31–5.
3. Ngan P, Kess B, Wilson S. Perception of discomfort by patients undergoing orthodontic treatment. Am J Orthod Dentofac Orthop. 1989;(96):47–53.
4. Krishnan V. Orthodontic pain: from causes to management--a review. Eur J Orthod. 2007;29(2):170–9.
5. Steen SL, Southard KA, Alan S, et al. An evaluation of preoperative ibuprofen for treatment of pain associated with orthodontic separator placement. Am J Orthod Dentofac Orthop. 2000;118(6):629–35.
6. Walker JB, Buring SM. NSAID impairment of orthodontic tooth movement. Ann Pharmacother. 2001;35(1):113–5.
7. Huang YY, Chen ACH, Carroll JD, et al. Biphasic dose response in low level lightherapy. Dose-Response. 2009;7(4):358–83.
8. Chung H, Dai T, Sharma SK, et al. The nuts and bolts of low-level laser (light) therapy. Ann Biomed Eng. 2013;40(2):516–33.
9. Karu T. Photobiology of low-power laser effects. Health Phys. 1989;56(5):691–704.
10. Hawkins D, Abrahamse H. Effect of multiple exposures of low-level laser therapy on the cellular responses of wounded human skin fibroblasts. Photomed Laser Surg. 2006;24(6):705–14.
11. Lim HM, Lew KKK, Tay DKL. A clinical investigation of the efficacy laser therapy in reducing orthodontic postadjustment pain. Am J Orthod Dentofac Orthop. 1995;108(6):614–22.
12. Tortamano A, Lenzi DC, Haddad ACSS, et al. Low-level laser therapy for pain caused by placement of the first orthodontic archwire: A randomized clinical trial. Am J Orthod Dentofac Orthop. 2009;136(5):662–7. Available from: http://dx.doi.org/10.1016/j.ajodo.2008.06.028
13. Marini I, Bartolucci ML, Bortolotti F, et al. The effect of diode superpulsed low-level laser therapy on experimental orthodontic pain caused by elastomeric separators: a randomized controlled clinical trial. Lasers Med Sci. 2015;30(1):35–41.
14. Nóbrega C, Da Silva EMK, De MacEdo CR. Low-level laser therapy for treatment of pain associated with orthodontic elastomeric separator placement: A placebo-controlled randomized double-blind clinical trial. Photomed Laser Surg. 2013;31(1):10–6.
15. Erdinç AME, Dinçer B. Perception of pain during orthodontic treatment with fixed appliances. Eur J Orthod. 2004;1026(1):79–85.
16. Turhani D, Scheriau M, Kapral D, et al. Pain relief by single low-level laser irradiation in orthodontic patients undergoing fixed appliance therapy. Am J Orthod Dentofac Orthop. 2006;130(3):371–7.
17. Varella AM, Revankar AV, Patil AK. Low-level laser therapy increases interleukin-1β in gingival crevicular fluid and enhances the rate of orthodontic tooth movement. Am J Orthod Dentofac Orthop. 2018;154(4):535-544.e5. Available from: https://doi.org/10.1016/j.ajodo.2018.01.012
18. AlSayed Hasan MMA, Sultan K, Hamadah O. Evaluating low-level laser therapy effect on reducing orthodontic pain using two laser energy values: a split-mouth randomized placebo-controlled trial. Eur J Orthod. 2018;40(1):23–8.
19. Aras MH, Bozdag Z, Demir T, et al. Effects of low-level laser therapy on changes in inflammation and in the activity of osteoblasts in the expanded premaxillary suture in an ovariectomized rat model. Photomed Laser Surg. 2015;33(3):136–44.
20. Tehranchi A, Fekrazad R, Zafar M, et al. Evaluation of the effects of CO2 laser on debonding of orthodontics porcelain brackets vs. the conventional method. Lasers Med Sci. 2011;26(5):563–7.
21. Strobl K, Bahns TL, Wiliham L, et al. Laser-aided debonding of orthodontic ceramic brackets. Am J Orthod Dentofac Orthop. 1992;101(2):152–8.
22. Thomas BW, Hook CR. Draughn RA. Laser-aided degradation of composite resin. Angle Orthod. 1996;66(4):281–6.
23. Shi Q, Yang S, Jia F, et al Does low level laser therapy relieve the pain caused by the placement of the orthodontic separators? - A meta-analysis. Head Face

Med. 2015;11(1):1–9. Available from: http://dx.doi.org/10.1186/s13005-015-0085-6
24. Artés-Ribas M, Arnabat-Dominguez J, Puigdollers A. Analgesic effect of a low-level laser therapy (830 nm) in early orthodontic treatment. Lasers Med Sci. 2013;28(1):335–41.
25. Kim WT, Bayome M, Park JB, et al. Effect of frequent laser irradiation on orthodontic pain a single-blind randomized clinical trial. Angle Orthod. 2013;83(4):611–6.
26. Abtahi SM, Mousavi SA, Shafaee H, et al. Effect of low-level laser therapy on dental pain induced by separator force in orthodontic treatment. Dent Res J (Isfahan). 2013;10(5):647–51.
27. Furquim RD, Pascotto RC, Neto JR, et al. Low-level laser therapy effects on pain perception related to the use of orthodontic elastomeric separators. Dental Press J Orthod. 2015;20(3):37–42.
28. Cronshaw M, Parker S, Anagnostaki E, et al. Systematic review of orthodontic treatment management with photobiomodulation therapy. Photobiomodul Photomed Laser Surg. 2019;37(12):photob.2019.4702. Available from: https://www.liebertpub.com/doi/10.1089/photob.2019.4702
29. Qamruddin I, Alam MK, Fida M, et al. Effect of a single dose of low-level laser therapy on spontaneous and chewing pain caused by elastomeric separators. Am J Orthod Dentofac Orthop. 2016;149(1):62–6. Available from: http://dx.doi.org/10.1016/j.ajodo.2015.06.024
30. Gupta S, Ahuja S, Bhambri E, et al. Evaluating the effect of low-level laser therapy on pain induced by orthodontic separation: a randomized split-mouth clinical trial. Lasers Dent Sci. 2018;2(4):221–8.
31. Price DD, McGrath PA, Rafii A, et al. The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. Pain. 1983;17(1):45–56.
32. Martins IP, Martins RP, Caldas SGFR, et al. Low-level laser therapy (830 nm) on orthodontic pain: blinded randomized clinical trial. Lasers Med Sci. 2019;34(2):281–6.
33. Sandhu SS, Leckie G. Orthodontic pain trajectories in adolescents: Between-subject and within-subject variability in pain perception. Am J Orthod Dentofac Orthop [Internet]. 2016;149(4):491-500.e4. Available from: http://dx.doi.org/10.1016/j.ajodo.2015.10.020
34. Fujiyama K, Deguchi T, Murakami T, et al. Clinical effect of CO2 laser in reducing pain in orthodontics. Angle Orthod. 2008;78(2):299–303.
35. Jimenez EEO, Hilgenberg SP, Rastelli MC, et al. Rebonding of unused brackets with different orthodontic adhesives. Dental Press J Orthod [Internet]. 2012;17(2):69–76. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S2176-94512012000200014&lng=en&tlng=en
36. Almallah MME, Almahd WH, Hajeer MY. Evaluation of the use of low-level laser therapy in pain control in orthodontic patients: A randomized split-mouth clinical trial. J Clin Diagnostic Res. 2016;10(11):ZC23–8.
37. Eslamian L, Borzabadi-Farahani A, Hassanzadeh-Azhiri A, et al. The effect of 810-nm low-level laser therapy on pain caused by orthodontic elastomeric separators. Lasers Med Sci. 2014;29(2):559–64.

PEER REVIEW

CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

FUNDING

None

ETHICS COMMITTEE APPROVAL

Ethical approval was obtained from the Ethical Committee of the Clinical Hospital Center of Rijeka, Croatia (003-05/2/-1-/22, 2170-29-02/1-20-2).

Figure 1: Flow diagram of the sample

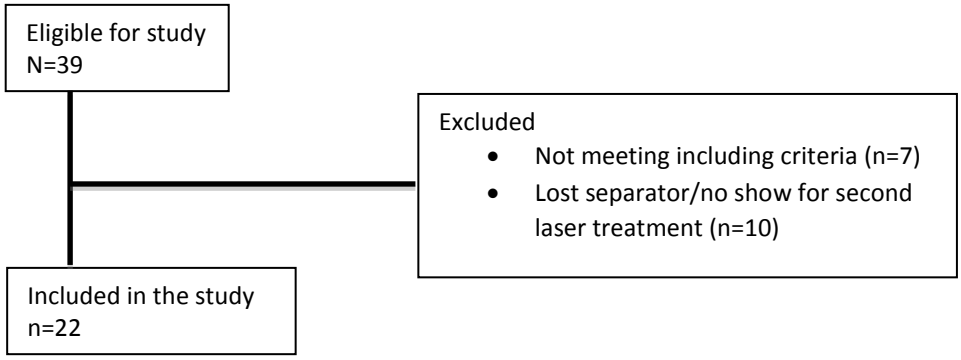

Table 3: Comparison of pain in the PBM and placebo groups

		Right					**Left**					
Hour/day	N[a]	Mean	SD[a]	Min[a]	Max[a]	Median	Mean	SD	Min	Max	Median	p[a]
5min (TO)	22	13.14	12.8	0	50	8.5	10.68	9.66	0	36	9	0.36
12 hours (T1)	22	30.91	23.7	0	76	25.5	35.32	26.2	1	80	33.5	0.38
24 hours (T2)	22	32.64	22.5	4	86	29	38.18	23.4	5	95	33	*0.01
2 day (T3)	22	26.27	21.4	0	86	18.5	29.59	22.4	0	97	31.5	0.29
3 day (T4)	22	12.82	17.6	0	68	5.5	14	22.8	0	90	7	0.56