BMJ Open Sport & Exercise Medicine

Injury rate and characteristics in Japanese male professional ice hockey players: prospective study of 60 players over 10 seasons

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To cite: Suzuki K, Yoneoka D, Terada M, *et al*. Injury rate and characteristics in Japanese male professional ice hockey players: prospective study of 60 players over 10 seasons. *BMJ Open Sport & Exercise Medicine* 2024;**10**:e001720. doi:10.1136/bmjsem-2023-001720

Accepted 11 March 2024

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ABSTRACT

Objectives We aimed to assess the injury rate and characteristics in Japanese male professional ice hockey players.

Methods This study involved an inclusive cohort of male ice hockey players from a Japanese professional team competing in the 2010–2011 through the 2019–2020 seasons. An injury was defined as the 'time-loss and medical attention' definition of the International Ice Hockey Federation. All injuries that occurred during games and practice sessions were recorded daily on injury charts by the team athletic trainers and/or physician. Game-related injury rates were analysed using both the athlete-at-risk (AAR) and time on ice (TOI) methods.

Results Sixty players were included in the study. A total of 479 injuries were recorded, with 307 (64%) occurring during 451 games and 172 (36%) occurring during the practice sessions. The game-related injury rates obtained using the AAR and TOI methods were not statistically different (p>0.05): 115.3 (95% CI 107.1 to 123.1) and 116.8 (95% CI 109.9 to 124.7) per 1000 player-game hours, respectively. Most injuries involved the upper extremities (39.9% game-related, 32.6% practice-related), followed by the lower extremities (23.5% game-related, 32.5% practice-related). The most frequent mechanism of game-related injury was body checking (45.4%).

Conclusion We observed a higher injury rate in a Japanese male professional team compared with rates reported in other leagues. The reported injury characteristics should help to improve injury prevention strategies that should target shoulder dislocations caused by body checking, and finger or wrist fractures resulting from contact with a hockey stick or puck impact.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Injury rates in men's elite ice hockey vary widely between 13.8 and 121.0 per 1000 player-game hours across studies owing to inconsistent injury definitions and athlete exposure.
⇒ Regardless of the severity of the injury, the most common mechanisms of injury were body checking, followed by contact with a hockey stick and puck impact.

WHAT THIS STUDY ADDS

⇒ The injury rate obtained using the definition of injury of the International Ice Hockey Federation and the athlete-at-risk method was higher in a Japanese male professional ice hockey team than that previously published in other leagues.
⇒ On assessing a Japanese male professional ice hockey team, injury rates did not differ significantly between the athlete-at-risk method: 115.3 (95% CI 107.4 to 23.1) per 1000 player-game hours and the time on ice method: 116.8 (95% CI 109.9 to 124.7) per 1000 player-game hours.
⇒ The predominant game-related injuries of major severity in the upper extremities were shoulder joint dislocations or subluxations caused by body checking and finger or wrist fractures resulting from contact with a hockey stick or puck impact.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Injury rate estimates should be standardised using the injury definition established by the International Ice Hockey Federation and the athlete-at-risk method to facilitate comparisons between studies.
⇒ Although improvements in protective equipment are important for face or finger injuries, players' and staff's education and game rule changes may be more crucial as preventive strategies for limiting injuries of major severity caused by illegal body checking or head-targeted hits.

INTRODUCTION

Injuries are common in contact and collision sports, such as ice hockey, where players move at high skating velocities and rapidly change direction. Injuries in men's ice hockey have been reported previously, with injury rates in competitive ice hockey ranging between 13.8 and 121.0 per 1000 player-game hours, depending on parameters such as injury definition and player exposure time estimates.[1]

Definition of injury is a crucial component in calculating the injury rate. While numerous consensus statements have aimed to standardise surveillance methodology, significant

variation continues to exist in the current definitions of injury.[2] An injury that results in a player being unable to complete the current or future game or training session is a 'time-loss' injury, and an injury that results in an athlete receiving medical attention is referred to as 'medical attention'.[2] Finally, 'any complaint' is defined as injuries that are recorded, regardless of the severity or amount of time lost from competition.[2] The 'time loss' definition is the easiest to use because time loss is easy to track. However, it leads to the fewest reported incidents as it does not account for athletes who continue to train and play while injured. The 'medical attention' definition can be considered as subjective, as each player can have different levels of injury perceptions before requiring medical attention, thus injury can be interpreted differently by individuals. Recently, the International Ice Hockey Federation (IIHF) provided a more specific definition of injury based on 'time-loss' and 'medical attention' with clearer clinical conditions.[3] According to the IIHF's definition of injury, 'time-loss' injuries encompass injuries that prevented the player from returning to the same practice or game or caused the player to miss a subsequent practice or game, and 'medical attention' injuries include all lacerations that required sutures, all dental injuries, all concussions and all fractures.[3] This definition would likely ensure completeness and accuracy of the data, especially for game-related injuries.

Athlete exposure is the second component of the injury rate. Two common methods are typically used to estimate game exposure times to calculate the injury rate in ice hockey.[4] The first method to estimate team-level exposure time is the athlete-at-risk (AAR) method, in which the number of players on the ice is multiplied by either the number of games or the number of game hours that the team has played.[3 5–11] The second method is the athlete participation (AP) method, also called 'athlete exposure',[12–15] where participation is defined as players on the game roster, regardless of whether they played or not during the game. The major difference between the two methods is the number of participants included in the injury rate calculation. The AP method underestimates the injury rate, because it overestimates exposure time by including all players on the game roster, irrespective of whether they played or not. On the contrary, the AAR method includes only the number of players at risk on the ice during the game. In an ice hockey game, five players from each team play on the ice, with a free exchange between position players and a goalie throughout the game. A team that received a penalty may be called to play 'short-handed', meaning that a penalised player is ruled off the ice for 2–5 min while the opposing team is on a 'power play'. The 'power play' expires after the designated time or if the advantaged team scores during their 'power play'. During overtime, four players from each team play on the ice. Ignoring the 'power plays' of the opponent teams and overtime minutes, six players are assumed to be on the ice at any one time for 1 hour in each game. Most researchers have used the AAR method to calculate injury rates in ice hockey while ignoring penalty minutes and over time. To analyse individual risk factors, individual-level exposure time rather than team exposure time must be recorded. Recently, McKay *et al*[12] reported the injury rate based on the actual time on ice (TOI); the TOI was calculated based on the number of minutes and seconds that each individual played per game over the season.

In this study, we aimed to report the game-related injury rates, and characteristics of both game-related and practice-related injuries in a professional ice hockey team in Japan. In addition, we compared the injury rates between the AAR and TOI methods.

METHODS

Study design and overall procedure

This longitudinal observational study was conducted to investigate and document all injuries sustained by players of a Japanese male professional ice hockey team during official games and practice sessions over 10 seasons (2010–2011 to 2019–2020).

The official games included the Asia League regular season and playoff games. In recent years, one Russian, three Korean and four Japanese teams have participated in the Asia League. Each team played 30–48 games during the regular season and 2–12 games during playoffs from September to March. The training camp started in June and included drills on ice and in the field, weight training and preseason games (range: 4–6 games). During the season, two games were regularly played on weekends, and on/off-ice practice sessions were conducted 3–4 times weekly.

Participants

Players who had played for the team for at least one season during the 10-year period were included in this study. The team has been competing in the Asia League since its establishment in 2003 and has won the championship thrice.

Injury definition

An injury was defined in accordance with the injury report system form of the IIHF[3] as any injury sustained during practice or a game.

Injury severity was classified as minor, moderate or major based on the duration of missed game participation: <1 week, 1–4 weeks and >4 weeks, respectively.[7] Any injury that required surgery after the season, such as anterior shoulder dislocation, was defined as a major injury. A fracture was defined as major even when the player returned to the game with a brace immediately after the injury or surgery. In cases where an injury occurred at the end of the season, injury severity was estimated based on the player's follow-up at the clinic.

Subsequent injuries to the same location of the body as the index injury are recurrences if the index injury has healed/fully recovered; they are exacerbations if the index injury has not yet healed/fully recovered.[16]

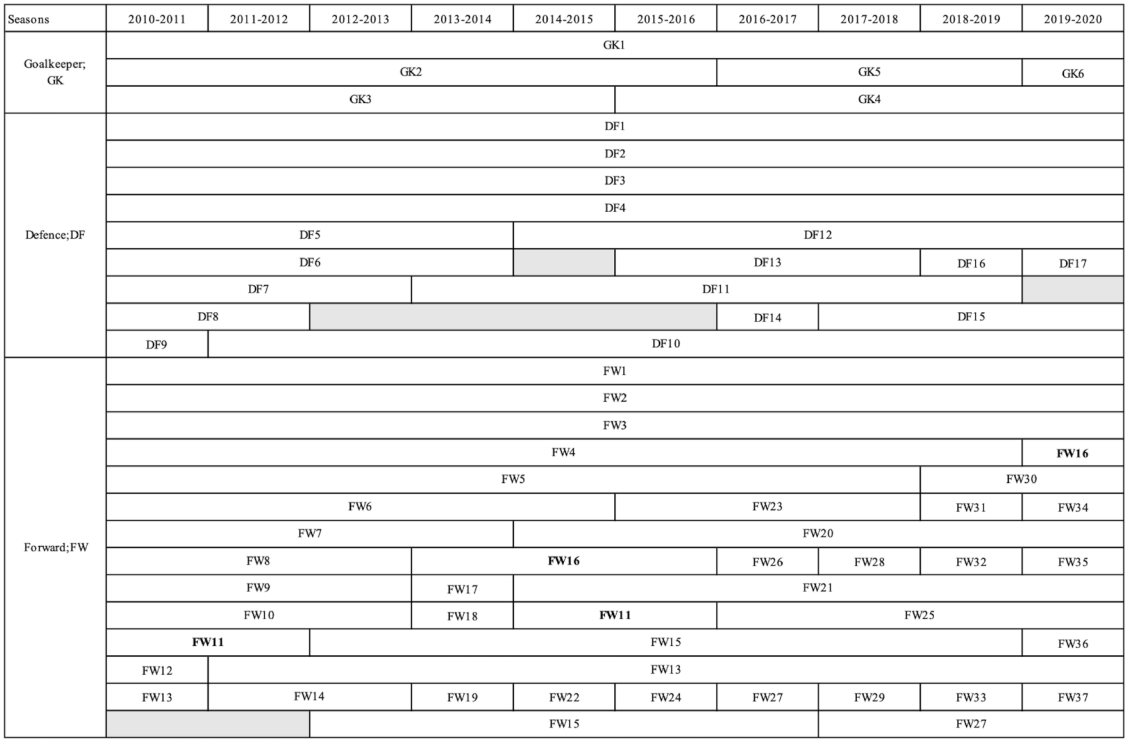

Figure 1 Sixty players were included in this study: 37 forwards, 17 defencemen and 6 goalies. Fowards 11 and 16 played for the team twice.

A recurrence was recorded as a new injury, whereas an exacerbation was recorded as the same injury.

Data collection

All injuries were recorded daily on injury charts by the team athletic trainer or physician (KS). The team physicians followed up on the injured players until they returned to the previous level. The injury charts for game-related injuries included the player's position, injured body part, period within the game, injury mechanism, final diagnosis, treatment and clinical results. Additionally, whether the game-related injury was due to penalised illegal activities was recorded. The injury chart for practice-related injuries was identical in content to the one for game-related injuries, except for not including the practice time or period within the practice game during which the injury occurred.

Table 1 Ice hockey injuries during 10 seasons

Season	Practice injuries (n)	Game injuries (n)	Games (n)	6 players-time	Overtime	Penalty time	AAR injury rate	TOI injury rate
10–11	19	25	40	34:50:06	0:52:08	5:09:54	104.2	104.9
11–12	19	32	43	38:04:01	0:40:49	4:55:59	124.0	125.1
12–13	10	30	49	42:48:21	0:34:42	6:11:39	102.0	103.4
13–14	22	36	49	42:27:09	0:28:04	6:32:51	122.4	125.2
14–15	17	35	51	44:40:47	0:53:33	6:19:13	114.4	115.4
15–16	12	32	50	42:56:10	0:26:17	7:03:50	106.7	109.2
16–17	19	32	50	43:41:10	0:32:25	6:18:50	106.7	108.2
17–18	20	34	40	35:39:55	0:26:33	4:20:05	141.7	143.2
18–19	16	24	37	32:32:41	0:37:51	4:27:19	108.1	109.2
19–20	18	27	39	34:37:36	0:20:41	4:22:24	115.4	116.9
Total	172	307	448			AVG	115.3	116.8
						95% CI	107.4 to 123.1	109.9 to 124.7

AAR, athlete-at-risk injury rate/1000 player-game hours; AVG, average; TOI, time-on-ice injury rate/1000 player-game hours .

Table 2 All injuries and injuries of major severity according to the body part

All injuries	Concussion	Head	Neck	Face	Shoulder/Elbow	Finger/ Wrist	Back	Chest/Abdomen	Hip/Groin	Knee	Ankle/ Foot	Total
Game, n (%)	19 (6.2)*	1 (0.3)	7 (2.3)	43 (13.7)	52 (17.0)	70 (22.9)	8 (2.8)*	19 (6.2)	16 (5.2)	39 (12.7)	33 (10.8)*	307
Practice, n (%)	0 (0)*	0 (0)	2 (1.2)	18 (10.7)	22 (12.8)	34 (19.8)	13 (7.6)*	12 (7.0)	15 (8.7)	19 (11.0)	37 (21.5)*	172
Injuries of major severity												
Game, n (%)	3 (5.8)	0 (0)	0 (0)	4 (7.7)	12 (23.1)	11 (21.2)	2 (3.8)	2 (3.8)	4 (7.7)	7 (13.5)	7 (13.5)	52
Practice, n (%)	0 (0)	0 (0)	0 (0)	0 (0)	4 (28.6)	4 (28.6)	0 (0)	0 (0)	1 (7.1)	3 (21.4)	2 (14.3)	14

*P≤0.05.

Injury rate

The injury rate was estimated by calculating the number of injuries per 1000 hours of game participation. The injury rates were calculated using two exposure times: with and without considering the penalty minutes and overtime.[1] Injury rates were only calculated for game-related injuries, whereas not for practice-related injuries.

AAR method

As in previous studies,[3 6–11] we defined participation as the time where six players were on the ice for a 1-hour game (20 min for three periods, ignoring 'penalty minutes' and overtime minutes): six players×1 hour×number of games.[4]

TOI method

We calculated the actual participation time using the time during which six players were on the ice without penalty and that during which five or four players were on the ice during 'short-handed' minutes, including overtime (six players×playing time without penalty time+5 players×'short-handed' minutes+4 players×overtime). Although the individual playing time was not recorded on the electronic game record in the Asia League, the 'short-handed' minutes, during which one or two penalised players remained in the penalty box, were recorded.

Statistical methods

Welch's t-test, χ^2 test and Fisher's exact test were implemented to statistically examine the following differences between groups: injury characteristics between practice-related and game-related injuries (player's position, part of the body injured and injury mechanism); injury rate between the AAR and TOI; injury rate between different player positions (forwards, defencemen and goalies) and the number of injuries between first, second and third periods of play. Bonferroni correction was applied to control error rates in multiple test groups, in which the p values were multiplied by the number of comparisons. Data analyses were performed using the statistical software R V.3.6 (Free Software Foundation's GNU General Public License, R Foundation for Statistical Computing, Vienna, Austria). Statistical significance was set at p≤0.05.

Patient and public involvement

Players or the general public were not involved in the planning, execution, reporting or dissemination of our research.

RESULTS

Participants

Sixty players, played for at least one of the 10 seasons, were included in this study: 37 forwards, 17 defencemen and 6 goalies (figure 1). The average player age was 26.7 (range: 18–39) years; the average height and weight of players were 178.3 (range: 170–192) cm and 78.9 (range: 69–95) kg, respectively. The average playing duration for all players was 4.1 years (range: 1–10).

Injuries

A total of 479 injuries was recorded: 307 (64%) occurred during games and 172 (36%) occurred during practice sessions (table 1).

The AAR and TOI injury rates were 115.3 (95% CI 107.4 to 123.1) and 116.8 (95% CI 109.9 to 124.7) per

Table 3 Injuries according to mechanism

	Body checking	Hit by puck	Hit by stick	Collision with boards	Others	Total	Penalty-related
Games, n (%)	139 (45.4)*	48 (15.4)	46 (15.0)	38 (12.4)	36 (11.5)*	307	50 (16.3)
Practice, n (%)	51 (29.7)*	27 (15.7)	20 (11.6)	14 (8.1)	60 (34.9)*	172	4 (2.3)

*P≤0.05.

Table 4 Injuries according to severity

	Minor	Moderate	Major	Total
Game, n (%)	132 (42.8)*	123 (40.2)	52 (20.0)*	307
Practice, n (%)	94 (54.7)*	64 (37.2)	14 (8.1)	172

*P≤0.05.

1000 player-game hours, respectively; however, the difference was not significant (p>0.05).

Injuries by body area

During games, the fingers and wrist were the most injured body parts, followed by the shoulder/elbow and face. Concussions were observed in 19 (6.2%) players. Concussions were not observed during practice sessions. Ankle/Foot and back injuries occurred more frequently during practice sessions than during games (table 2).

Injury mechanism

Regarding game-related injuries, the most frequent mechanism of injury was body checking, followed by contact with hockey stick, puck impact and collisions with the boards (table 3). Fifty (16.3%) injuries were penalty-related.

Practice-related injuries were significantly less likely to result from body checking, while those caused by 'other mechanism' were significantly more frequent compared with game-related injuries. Considering 'other mechanisms' (34.9%), overuse-type or insidious-onset injuries occurred more frequently during practice sessions than during games. Insidious-onset ankle pain following cross-country running or low back and thigh muscle soreness at the beginning of the training season were observed.

Injury severity

Minor severity injuries were significantly more frequent during practice sessions, whereas major severity injuries were significantly more frequent during games (table 4).

In major severity injuries during games, the most affected body parts were the shoulder/elbow (23.1%), followed by finger/wrist (21.2%), knee (13.5%) and ankle/foot (13.5%) (table 2).

Player position and period

No significant differences were observed in the injury rates between forwards and defencemen. Goalies had a lower injury rate than the forwards and defencemen (p≤0.05; table 5).

Regarding game time, 74 (24%), 127 (41%) and 103 (34%) injuries occurred during the first, second and third periods, respectively. Three injuries occurred during overtime. No significant differences were found between periods (p>0.05).

DISCUSSION

During the 10-season study period, 60 players sustained 307 game-related injuries in 448 games and 172 practice-related injuries.

Injury rate

The injury rate calculated using the AAR was 115.3 per 1000 player-game hours in this study. Our study revealed a higher injury rate than those reported in the NHL (49.4 per 1000 player-game hours),[12] North American collegiate players (47.6 per 1000 player-game hours)[13] and European leagues (66–88.6 per 1000 player-game hours).[5 7–10] This discrepancy could be attributed to the definition of injury employed in these different studies, which did not include non-time-loss injuries, such as facial lacerations and dental injuries that players continued to play with despite being injured. Lorentzon *et al*[7] included facial lacerations requiring treatment and reported that the injury rate increased from 78.4 to 100.2 per 1000 player-game hours, similar to our findings. The IIHF describes reportable injuries as 'time-loss' injuries and clear 'medical attention' injuries.[3] The 'medical attention' definition could be considered as subjective and can be interpreted differently by individuals. Therefore, the IIHF's definition provided a more specific 'medical attention' definition. Accordingly, the IIHF's definition of injury is appropriate for identifying injuries, especially game-related injuries, in elite men's ice hockey.

We compared the AAR and TOI methods to investigate whether the inclusion of penalty minutes and overtime periods has an impact on the two injury rates. Although the TOI injury rate (116.8 per 1000 player-game hours) was higher than the AAR injury rate (115.3 per 1000 player-game hours), there were no significant differences

Table 5 Injuries according to player position

	Forward	Defenceman	Goalie	Total
Practice, n (%)	96 (55.8)	65 (37.8)	11 (6.4)	172
Game, n (%)	177 (57.7)	25 (40.8)	5 (1.8)	307
AAR injury rate/1000 player-game hours	130.5*	138.2*	11.6*	115.3
AVG (95% CI)	(126.6 to 144.4)	(126.2 to 150.2)	(0.1 to 23.0)	(107.4 to 123.1)

*P≤0.05.
AAR, athlete-at-risk; AVG, average.

between them. When calculating the true risk of injury for an individual player, the injuries and precise TOI of each player should ideally be measured using a computer-based method in the future.[17] When individual-level data are unavailable, the AAR method closely replicates the results of the individual-level exposure time calculations.

Injuries by body area/injury mechanisms

The most injured body parts during games were the finger/wrist, shoulder/elbow and face. The mechanism of finger or wrist fractures was mostly attributed to contact with hockey stick and puck impact. The most common mechanism of shoulder injuries was body checking. All players with shoulder dislocation or subluxation returned to play during the same season while wearing a shoulder harness with abduction and external rotation limitation strapping. All affected players experienced re-subluxation (no re-dislocation cases) during the same season. Although high recurrence rates have been reported for same-season return to sports after non-surgical treatment,[18] no report has evaluated recurrent instability in contact and collision athletes within the same season after an index injury.

During practice sessions, ankle and foot injuries were the most frequent. The ankles and feet were often subject to sprains or overuse on the practice field. Moreover, overuse-type back pain occurred more frequently during practice sessions than during actual games.

Facial injuries were predominantly lacerations requiring sutures, followed by three nasal fractures and one mandibular fracture. No eye injury was noted in this study, and all players wore a helmet with a half visor during games. Although full and partial face protection substantially reduced eye and facial injuries, concussion rates remained unaltered.[19 20]

The incidence of concussion during the games analysed in this study was 6.2 per 1000 game player-hours, which is similar to the incidence of 5.6 per 1000 game player-hours (559 concussions in 16 482 NHL games) noted in the study by Benson *et al*[21] and of 4.0 per 1000 game player-hours (160 concussions/2 teams in 3293 IIHF games) noted in the study by Tuominen *et al*.[22]

Injury prevention

The major severity injuries of the shoulder and knee were predominantly caused by body checking. Tuominen *et al*[3] reported that arenas with flexible boards and glass reduced the risk of injury by 29%. To prevent concussions in ice hockey players in the NHL, Rule 48 was introduced in the 2010–2011 season based on video analyses of concussions during games: 'A lateral or blindside hit to an opponent where the head is targeted and/or the principal point of contact is not permitted'.[23–25] Hutchison *et al*[26] reported that the number of concussions following direct hits to the lateral aspect of the head was reduced following the implementation of Rule 48. Educating players and staff and changing the game rules, such as Rule 48, may be more crucial as preventive strategies to limit injuries of major severity caused by dangerous or illegal body checking.

The high number of finger/hand fractures observed in the present study could have been prevented by improving the glove design. While hockey gloves are designed to protect players against flying pucks and opponents' hockey sticks, featuring dorsal padding and shells for the thumb and little finger, additional hard-sided shells for the remaining fingers and fingertip protection should be applied.

Clinical implications

The injury rate, as determined using the injury definition by IIHF and the AAR method, was higher than those documented in previous reports. Although improvements in protective equipment are important for face or finger injuries, educating players and staff and changing the game rules may be more crucial as preventive strategies for limiting injuries of major severity caused by dangerous or illegal body checking.

Limitations

The main limitation of our study is the use of a cohort of ice hockey players from a single team. Similar investigations with a larger sample of teams are needed to increase the statistical power and improve generalisability. However, we conducted data collection under the supervision of a team physician over 10 seasons, ensuring a study outcome with minimal bias. We also attempted to standardise the data using the AAR and TOI methods and evaluated the differences between these two methods; thus, our study remains valuable. Additionally, it would have been interesting to obtain detailed information combining game-specific and practice-specific risk factors for injury, as well as evidence on the mechanisms underlying ice hockey injuries. Nevertheless, the present study provides valuable results on ice hockey-related injuries that can be compared and applied in current and future research.

CONCLUSIONS

The injury rate of game-related injuries in a single ice hockey team in the Asia League was relatively higher than that recorded in previous reports from other leagues. The upper extremities were the most frequently injured body parts during the games and practice sessions. Although the TOI injury rate was higher than the AAR injury rate, there was no significant difference between the two estimation methods used in each season.

Acknowledgements The authors would like to thank Scott Rodeo, MD (Hospital for Special Surgery, New York City, New York, USA), for his review and advice regarding this paper and Editage (www.editage.com) for English language editing.

Contributors KS contributed to the study proposal development. KS, MT, KK, TK and YS contributed to the data collection, entry and cleaning. KS and DY contributed to the data analysis and interpretation of the study results. All authors reviewed and agreed on the manuscript. KS is the study guarantor.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Ethical approval was received from the Research Ethics Boards at the Oji General Hospital (OGH2020-16). Participants provided informed consent prior to participation.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information.

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