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Response of wedge grafting in *Adenium (Adenium spp*) types under controlled condition

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Abstract
The present Experiment was conducted at College of Horticulture, Dr. B.S.K.K.V., Dapoli, Dist. Ratnagiri (Maharashtra) during Feb-March of academic year 2024-202***5***. The experiment was laid out in Randomized Block Design (RBD) in ten treatment and three replications. The findings showed that treatment T_2 ADBSKKVCOH- 12 Light Red (Double) maximum (2.40) number of sprouts **,** Sprouting percentage (93.33%), Leaf Length (cm) (8.02 cm)**,** Leaf Breadth (cm) (4.47cm)**,** Average Leaf Area (cm^2) (21.60 cm^2)**,** Girth of scion uniform height (mm) (8.63 mm)**,** Girth of Stem (mm)**,** (9.43 mm)**,** Girth of Caudex (mm) (24.40 mm)**,** Height of graft from graft union (cm) (12.18 mm)**,** Absolute Growth Rate (cm/day) (0.087 cm/day)**,** Relative Growth Rate(cm/cm/day) (0.0457cm/cm/day)**,** Survival percentage (88.33%) Number of shoots observed in treatment T_8 ADBSKKVCOH-19 Purple Red (Single) ((1.86)**,** length of shoot (cm) (2.73)**,** Number of days required to sprouting (11.43), Number of leaves per plant observed in treatment T_7 ADBSKKVCOH-17 Red (Double) (19.39).

Keywords: Wedge grafting, *adenium*, controlled conditions, sprouting percentage, growth parameters, survival rate, scion varieties, randomized block design, horticulture, Maharashtra

1. Introduction
Adenium is a belonging to the Apocynaceae family. It is a one of the best flowering pot plant with great relevance in the ornamental market due to its sculptural aspect, resistance to drought stress along with very showy flowers. The *adenium* distinctive caudex (swollen base) is globe shaped to conical, tapering into narrow, divided cells. Its irregular branching pattern creates a unique, aesthetically pleasing shape, ideal for bonsai cultivation. *Adenium* hybrids are mostly multiplied through grafting in which (*Adenuim* spp) is used as rootstock. Seed propagation of *adenium* exhibits progeny segregation, resulting in substantial phenotypic variability Wedge and flat grafting are the most widely adopted techniques for commercial scale *adenium* production. Notably, wedge grafting is the preferred method for large scale multiplication of *adenium* phenotypes due to its ease of execution and high success rates.

Grafting helps *adenium* plants adopt to challenging growing conditions by utilizing rootstocks with specific environmental tolerances. For instance, grafting into drought tolerant rootstocks enhances the plant ability to endure water scarcity, while grafting into **c**old tolerant rootstocks improves winter hardiness in cooler climates. Grafted *adenium* plants may exhibit increased sensitivity to environmental stressors such as extreme temperatures, drought or water logging, particularly during the initial healing phase. Environmental conditions significantly impact grafting success rates and the overall health and vigour of grafted plants, necessitating careful monitoring and management by growers (Beshir *et al*., 2019) [1].

Wedge grafting enables growers to propagate specific *adenium* cultivars that possess desirable traits such as distinctive flower colours, unique shapes, or specific growth patterns. This technique ensures genetic stability, preserving the characteristics of the parent plant in the propagated offspring. Grafting onto disease resistant rootstocks helps to reduce the impact of soil borne pathogens and pests, enhancing plant health. Wedge grafting in *adenium* has a wide range of applications, including propagation, varietal enhancement, disease management, and conservation. This technique is essential in *adenium* cultivation, research, and commercial production, providing significant advantages for growers, brand researchers**.**

It allows growers to propagate a significant number of uniform plants with consistent traits, catering to the needs of nurseries, landscapers, and collectors.

2. Materials and Methods

The current studies entitled "Studies of wedge grafting in *adenium* (*Adenium spp*) types". The experiment was carried out at Hi-tech unit, College of Horticulture, Dapoli. Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, India, 415712.The experiment was laid out in Randomized Block Design with Ten treatment *viz*., T_1 ADBSKKVCOH-11 Purple Red (Single), T_2 ADBSKKVCOH-12 Light Red (Double), T_3 ADBSKKVCOH-13 Yellow Red Shade (Double), T4 ADBSKKVCOH-14 White with Red Border (Double), T_5 ADBSKKVCOH-15Yellow with Red Centre (Strips), T_6 ADBSKKVCOH-16 Light Pink (Single) T_7 ADBSKKVCOH-17 Red (Double),T_8 ADBSKKVCOH-19 Purple Red (Single), T_9 ADBSKKVCOH-21 Yellow with Pink (Strips), T_{10} ADBSKKVCOH-22 Red with Purple (Border) with three replications. For raising rootstock used seed as a planting material. Seeds are collected from mature pods contain average 50-60 seeds**.** These seeds are soaked in warm water for a minimum two to four hours. Seeds are sown in portray which contain cocopeat as a growing media, seeds are germinated within 7-11 days, germinating percentage about 80-90 percent. After two months, seedling are transplanted in polythene bag (15×410 cm). It contain Potting mixture, prepared by using two part of cocopeat, one part of protomeal, one part of coconut husk and bricks, and small quantity of Trichoderma with a pH range of 5.5-6.5 and used 6-7 months plant selected for grafting.

During the experiment observations were recorded such as Number of days required to first sprouting**,** Number of sprouts per plant**,** Sprouting percentage**,** Number of leaves per plant Leaf Length (cm)**,** Leaf Breadth (cm)**,** Average Leaf Area (cm^2)**,** Girth of scion uniform height(mm)**,** Girth of Stem (mm)**,** Girth of Caudex (mm)**,** Height of graft from graft union (cm)**,** Number of shoots**,** length of shoot (cm)**,** Absolute Growth Rate (cm/day)**,** Relative Growth Rate(cm/cm/day)**,** Survival percentage The generated data was subjected to statistical analysis method as suggested by Panse and Sukhatme

3. Results and Discussion

1. Number of days required to sprouting: It was observed that the average number of days required for first sprouting in all *adenium* treatments were 13.09 days. Treatment T_8 ADBSKKVCOH-19 Purple Red (Single) required minimum number of days (11.43) for first sprouting, where the maximum number of days (14.07) required for first sprouting in treatment T_2 ADBSKKVCOH-12 Light Red (Double). Different plant species have exhibit varying capacities for sprouting after grafting with factors such as rapid change climate, temperature, humidity and light playing a significant role in the success of joining of cambium and stages of scion for subsequent sprouting. These findings align closely with the results reported by, Halladamani *et al* (2023) [3] their result concluded that shortest duration for early scion sprouting (11.0) days in rose, Singh *et al*. (2023) mean duration of (14.57) days in *adenium* and Khanolkar *et al* (2024) [4] observed (11.47) days in *adenium*.

2. Number of sprout per plant

It is observed that maximum (2.40) number of sprouts was observed in treatment T_2 which was at par (2.33) with treatment T8. The minimum (1.46) number of sprout was found in treatment T_{10} ADBSKKVCOH-22 Red with Purple (Border). In treatment T_2, contain good amount of whitish latex which is facilitating scion and rootstock contact. Latex acts as a natural adhesive and enhancing tissue union during grafting. Similar results were found by Khanolkar *et al*. (2024) [4] observed maximum number of sprouts (1.93) days in *adenium*.

3. Sprouting percentage

The highest sprouting percentage observed maximum (93.33%) was recorded in treatment T_2 which was at par with treatment T_9 (88.33%), whereas minimum sprouting percentage (73.33%) was observed in treatmentT_6. Selecting the ideal time of month for grafting also increase the probability of a successful graft union development and subsequent sprouting, as this is when plants are actively growing and high sap flow is at the highest level. These findings aligned with Roy and Fatima maximum number of sprouting percentage (89%) in *adenium*. Khanolkar *et al*. (2024) [4] maximum number of sprouting percentage (91.67%) in *adenium*.

4. Number of leaves per plant

It was observed in maximum (19.39) number of leaves was found in treatment T_7 which was at par with T_4 (18.67), T_5 (18.57), T_{10} (18.01) and T_8 (17.63).The minimum number of leaves (15.73) was recorded in treatmentT_9.Production of leaves might be varied as per the characteristics of *adenium* genotypes. The wedge grafting method facilitates direct contact between the scion and rootstock's cambium layers which is crucial for establishing vascular connections and promoting nutrient and water transport. This technique ensures accurate alignment, enabling efficient exchange of nutrients and growth regulators, which promotes rapid healing and integration. Following grafting, both components initiate wound healing, leading to callus tissue formation and eventual union. By maximizing contact and minimizing air exposure, wedge grafting accelerates callus formation. This outcome is consistent with findings from Patil *et al* (2013) [8] maximum number of leaves observed (19.03) in guava. (2013). Khanolkar *et al*. (2024) [4] maximum (17.00) number of leaves observed in *adenium*.

5. Leaf Length (cm)

Maximum (8.02 cm), leaf length was observed in treatment T_2 which was at par (7.55 cm) with treatment T_{10}. While minimum (6.13 cm) leaf length was observed in treatment T_9. The successful integration of scion and rootstock is an important factor influencing leaf length in grafted plants. A well-established graft union facilitates efficient nutrient translocation, thereby promoting vigorous scion growth and the production of elongated leaves. Notably, leaf size and length exhibit variability among different genotypes. Similar findings was observed by Khatun *et al* (2013) [5] maximum (10.76cm) leaf length observed in jackfruitand and Khanolkar *et al*. (2024) [4] maximum (6.10 cm) leaf length observed in *adenium*.

6. Leaf Breadth (cm)

The treatment T_2 exhibited the statistically maximum (4.47cm) leaf breadthwhich was at par (3.86cm) with treatment T_1. Whereas minimum (2.89 cm) leaf breadth was found in treatmentT_{10}. Leaf size and breadth exhibit variability among different plant varieties, influenced by genetic makeup and rootstock health. Grafting can induce physiological changes, affecting nutrient uptake and hormone levels, which in turn impact leaf development and dimensions. These findings align with with Yadav *et al*. (2021) [12] maximum (6.22 cm) leaf Breadth observed in guava, Khanolkar *et al*. (2024) [4] maximum (3.73 cm) leaf Breadth observed in *adenium*.

7. Average Leaf Area (cm^2)

It observed that maximum (21.60 cm^2) was found in treatmentT_2 which was at par with treatmentT_7 (20.60 cm^2)**,** T_9 (20.54 cm^2) and T_5 (20.45 cm^2). The minimum (16.15 cm^2) leaf area was recorded in treatmentT_4. Grafting can influence leaf area in various ways, depending on plant species and grafting technique. Notably, treatmentT_2 exhibited maximum leaf length, with its leaf lamina covering the largest area. These findings are consistent with previous research by Mutteppa *et al*. (2017) [6] maximum (24.24 cm) leaf area observed in guava and other relevant, Khanolkar *et al*. (2024) [4] maximum (8.61 cm) leaf area observed in *adenium*.

8. Girth of scion uniform height (mm)

Treatment T_2 statistically exhibited the maximum (8.63 mm) scion girth which was at par with treatment T_3ADBSKKVCOH-13 Yellow Red Shade Double (8.26 mm) and T_1 (8.15 mm). Treatment T_{10} recorded the minimum (6.89 mm) scion girth. The scion girth response after grafting ***was*** influenced by factors such as scion and rootstock compatibility, grafting technique, and environmental conditions. Successful graft union establishment and integration of physiological activities between scion and rootstock determine scion girth. Optimal technique, plant materials, and climatic conditions are crucial for maximizing scion growth and girth. These findings align with previous research by Khanolkar *et al*. (2024) [4] show that maximum scion girth (11.07 mm) in *adenium*.

9. Girth of Stem (mm)

Highest (9.43 mm) stem girth was observed in treatment T_2 which was at par with treatmentT_7 (8.94 mm). The minimum (7.98 mm) stem girth was recorded in treatmentT_5. A well-integrated graft union fosters strong vascular connections between the rootstock and scion, promoting stronger growth and resulting in a thicker and more resilient stem. Treatment T_2 exhibited the maximum number of leaves, which can enhance hormone production auxins and cytokinins essential for growth and development. Increased hormone production can stimulate growth and improve grafted plant vigour. These findings align with Roy and Fatmi (2022) [10] reported that maximum (9.03 mm) girth of stem in *adenium* and Khanolkar *et al*. (2024) [4] found that maximum (9.46 mm) girth of stem in *adenium*.

10. Girth of Caudex (mm)

Maximum girth (24.40 mm) was recorded in treatment T_2which was at par with treatmentT_5 (22.79 mm) and T_6 (22.47 mm). While recorded the minimum caudex girth (19.66 mm) was recorded in treatment T_1. The rootstock's established system enhances nutrient, water uptake and soil less media (cocopeat + protomeal) promoting growth in the grafted plant. The integration of scion and rootstock leads to caudex thickening due to increased physiological support. Compatibility between scion and rootstock, grafting precision and post-graft care determine the ultimate increase in girth. Treatment T_2exhibited a stronger rootstock scion union. These findings align closely with the results reported by Khanolkar *et al*. (2024) [4] found that maximum (22.33 mm) caudex girth in *adenium*.

11. Height of graft from graft union (cm)

Maximum (12.18 mm) graft height was observed in treatment T_2while minimum graft height (9.70 mm) was found in treatment T_9. The success of grafting ***was*** often reflected in increasing plant height, attributed to enhanced physiological support from the rootstock and scion. ADBSKKVCOH-12 Light red (double) exhibited the highest scion and rootstock girth, as well as maximum plant height. This may be due to increased carbohydrate accumulation and favourable environmental conditions higher temperature and relative humidity) in shade, promoting metabolic activity and graft growth. These findings align with research by Khanolkar *et al*. (2024) [4] found that maximum (10.90 mm) caudex girth in *adenium*.

12. Number of shoots

Maximum (1.86) number of shoot was found in treatment T_8whereas, minimum (1.22) was recorded in treatment T_4. In *adenium*, the caudex serves as a nutrient storage organ, potentially promoting shoot development. Treatment T_8 exhibited the best caudex girth (20.50 mm). Compatibility between scion and rootstock is crucial, as it enables the rootstock's growth promoting factors to stimulate scion growth and shoot production. Environmental factors like light, water, and nutrients also impact plant development and shoot output after grafting. These findings are similar with research by Durgude (2013) [2] maximum (2.37) number of shoot was found in in guava, Khanolkar *et al*. (2024) [4] maximum (1.21) number of shoot was found in *adenium*.

13. Length of shoot (cm)

The maximum (2.73) length of shoot was found in treatment T_8 which was at par with T_2 (2.35 cm) and T_1 (2.10cm). Whereas, minimum height (1.23) was recorded in treatment T_3. TreatmentT_8 exhibited maximum shoot length, potentially due to compatibility between the rootstock and scion, which significantly influences growth patterns. This treatment also showed early sprouting (11.43 days). Effective grafting and compatibility are crucial for desired shoot height, while incompatibility can lead to poor development or graft failure. These findings are similar with research by Khanolkar *et al*. (2024) [4] maximum (3.53) number of shoot was found in *adenium*.

14. Absolute Growth Rate (cm/day)

It was observed maximum (0.087 cm/day) absolute growth rate on height basis was observed in treatment $T_2$and minimum (0.072 cm/day) in treatment T_1. The AGR values at 0-120 DAG, given in decreasing order. The compatibility between scion and rootstock is crucial for grafting success.

Effective grafting often results in faster plant growth due to factors like increased disease resilience, improved nutrient and water uptake, and the rootstock ability to support vigorous scion growth. In the case of ADBSKKVCOH-12 Light red (double), maximum height was attained with the highest growth rate across all months. These findings are similar with research by Khanolkar *et al*. (2024) [4] reported that maximum (0.0140 cm/day) RGR in *adenium*.

15. Relative Growth Rate (cm/cm/day)

It was observed maximum (0.0457cm/cm/day) relative growth rate on height basis was observed in treatment T_2 and minimum (0.0432 cm/cm/day) in treatment T_5. This investigation underscores the pivotal role of genetic traits in modulating Relative Growth Rate in grafted plants. Notably, ADBSKKVCOH-12 Light Red (Double) scions demonstrated exceptional growth performance, characterized by maximal height and augmented growth parameters, including plant height, scion and stem girth, leaf breath, leaf length and leaf area. These results corroborate recent findings by Khanolkar *et al*. (2024) [4] reported that maximum RGR (0.0323 cm/day) in *adenium*. Emphasizing the significance of genetic predisposition in determining grafting success and plant growth.

C (16). Survival percentage

It is observed that treatment T_2showed maximum survival percentage (88.33%) which is at par with treatment T_4 (81.67) and treatment T_6 (81.67%). Whereas treatment T_3 significantly recorded the minimum survival percentage (70.00%). In *adenium*, the natural sealing property of latex can facilitate wound protection and coverage during grafting. Moreover, the antimicrobial properties of *adenium* latex can mitigate pathogen entry and subsequent infection, thereby enhancing graft success. Notably, Treatment T_2 exhibited the highest latex content represent (Appendex-II), followed by treatment T_3. Graft success is also influenced by environmental factors such as light, humidity, and temperature. These findings are consistent with previous research by Singh *et al* (2023) highest (90.35%) survival rate in *adenium*, Khanolkar *et al*. (2024) [4] highest (86.67%) survival rate in *adenium* in *adenium*.

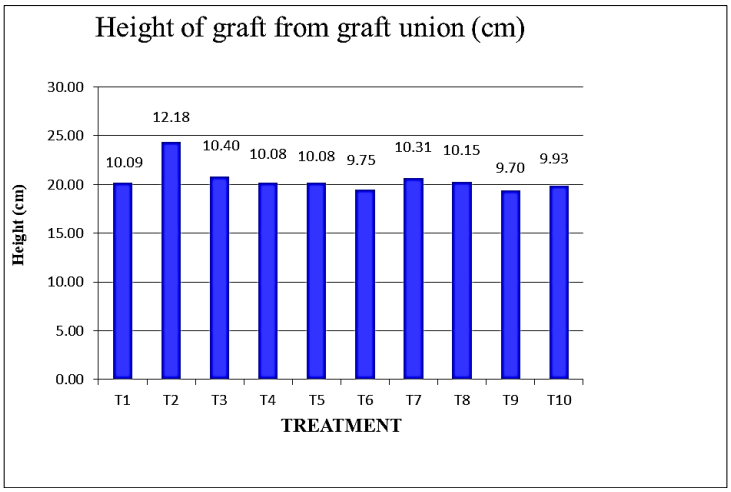

Fig 1: Height of graft from graft union (cm)

Sr. No.	Treatment	Treatment Details	No. of days required to sprouting	Number of sprouts per plant	Sprouting Percentage	Number of leaves per plant	Leaf Length (cm)	Leaf Breadth (cm)
1	T_1	ADBSKKVCOH-11 Purple Red (Single)	13.07	1.80	78.33	16.49	6.65	3.86
2	T_2	ADBSKKVCOH-12 Light Red (Double)	14.07	2.40	93.33	17.04	8.02	4.47
3	T_3	ADBSKKVCOH-13 Yellow Red Shade (Double)	12.73	1.53	78.33	17.40	7.11	3.50
4	T_4	ADBSKKVCOH-14 White with Red Border (Double)	12.87	1.73	78.33	18.67	6.61	3.06
5	T_5	ADBSKKVCOH-15 Yellow with Red Centre (Strips)	13.20	1.63	80.00	18.57	7.17	3.16
6	T_6	ADBSKKVCOH-16 Light Pink (Single)	13.33	1.67	73.33	17.02	6.20	3.29
7	T_7	ADBSKKVCOH-17 Red (Double)	13.53	1.47	76.67	19.39	7.00	3.37
8	T_8	ADBSKKVCOH-19 Purple Red (Single)	11.43	2.33	83.33	17.63	7.04	3.54
9	T_9	ADBSKKVCOH-21 Yellow with Pink (Strips)	12.67	1.67	88.33	15.73	6.13	3.34
10	T_{10}	ADBSKKVCOH-22 Red with Purple (Border)	14.00	1.46	81.67	18.01	7.55	2.89
Mean			13.09	1.77	81.17	17.60	6.95	3.45

Range			11.43 - 14.07	1.47 - 2.40	73.33-91.33	15.73- 19.39	6.13-8.02	2.89-4.47
'F'test			SIG	SIG	SIG	SIG	SIG	SIG
SEm±			0.35	0.13	2.90	0.61	0.28	0.26
CD at 5%			1.04	0.38	8.61	1.82	0.84	0.76

Sr. No	Treatment	Treatment Details	Leaf Area (cm^2)	Girth of Scion uniform height (mm)	Girth of Stem (mm)	Girth of Caudex (mm)	Height of graft from graft union (cm)
1	T_1	ADBSKKVCOH-11 Purple Red (Single)	19.51	8.15	8.67	19.66	10.09
2	T_2	ADBSKKVCOH-12 Light Red (Double)	21.60	8.***63***	9.43	24.40	12.18
3	T_3	ADBSKKVCOH-13 Yellow Red Shade (Double)	18.11	8.26	8.80	22.05	10.40
4	T_4	ADBSKKVCOH-14 White with Red Border (Double)	16.15	7.44	8.57	21.40	10.08
5	T_5	ADBSKKVCOH-15 Yellow with Red Centre (Strips)	20.45	7.43	7.98	22.79	10.08
6	T_6	ADBSKKVCOH-16 Light Pink (Single)	19.99	7.20	8.79	22.47	9.75
7	T_7	ADBSKKVCOH-17 Red (Double)	20.60	7.23	8.94	21.82	10.31
8	T_8	ADBSKKVCOH-19 Purple Red (Single)	16.70	7.13	8.49	20.50	10.15
9	T_9	ADBSKKVCOH-21 Yellow with Pink (Strips)	20.***54***	6.90	8.55	20.43	9.70
10	T_{10}	ADBSKKVCOH-22 Red with Purple (Border)	19.87	6.89	8.70	21.87	9.93
Mean			19.35	7.49	8.69	21.74	10.27
Range			16.15--21.60	6.89 -8.31	7.98 - 9.43	19.66- 24.50	9.70 - 12.18
'F'test			SIG	SIG	SIG	SIG	SIG
SEm±			0.48	0.34	0.20	0.65	0.42
CD at 5%			1.43	1.00	0.60	1.93	1.26

Sr. No	Treatment	Treatment Details	Number of shoot at 120 DAG	Length of shoot(cm) at 120 DAG	Absolute Growth Rate (cm/day)	Relative Growth Rate (cm/cm/day)	Survival Percentage (%).
1	T_1	ADBSKKVCOH-11 Purple Red (Single)	1.67	2.10	0.072	0.0440	76.67
2	T_2	ADBSKKVCOH-12 Light Red (Double)	1. 25	2.35	0.087	0.0457	88.33
3	T_3	ADBSKKVCOH-13 Yellow Red Shade (Double)	1.69	1.23	0.073	0.0454	70.00
4	T_4	ADBSKKVCOH-14 White with Red Border (Double)	1.22	1.56	0.076	0.0452	81.67
5	T_5	ADBSKKVCOH-15 Yellow with Red Centre (Strips)	1.30	1.24	0.085	0.0432	75.00
6	T_6	ADBSKKVCOH-16 Light Pink (Single)	1.24	1.90	0.075	0.0449	81.67
7	T_7	ADBSKKVCOH-17 Red (Double)	1.70	1.29	0.082	0.0449	76.67
8	T_8	ADBSKKVCOH-19 Purple Red (Single)	1.86	2.73	0.081	0.0455	78.33
9	T_9	ADBSKKVCOH-21 Yellow with Pink (Strips)	1.40	1.61	0.081	0.0446	73.33
10	T_{10}	ADBSKKVCOH-22 Red with Purple (Border)	1.63	1.48	0.074	0.0448	71.67
Mean			11.50.50	1.75	0.079	0.0448	77.00
Range			1.22-1.86	1.23 - 2.73			70. 00 83.33
'F'test			SIG	SIG			SIG
SEm±			0.15 0.1	0.22			2.79
CD at 5%			0.44	0.65			8.33

4. Conclusion

From present investigation it could be concluded that:-

Among the various *adenium* treatments T_2 ADBSKKVCOH-12, propagated by wedge grafting technique proved superior for the various growth parameters such as Number of sprout per plant (2.40), Sprouting percentage (93.33), Survival percentage 88.33%, Leaf length (8.02), Leaf breath (4.47) ,Leaf Area (21.60), Graft height (12.18) and stem girth (8.***63***) Scion girth (9.43), Caudex Girth , (24.40) Absolute Growth Rate (0.087), Relative Growth Rate (0.0457) and maximum B:C ratio 1.31.

The present investigation is suggestive and need to be further studied for appropriate recommendations. "As these finding are based on a one year study, futher research is necessary to validate and confirm the results"

Disclaimer (Artificial Intelligence)

In this manuscript there is no use of Al technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text to image generators.

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